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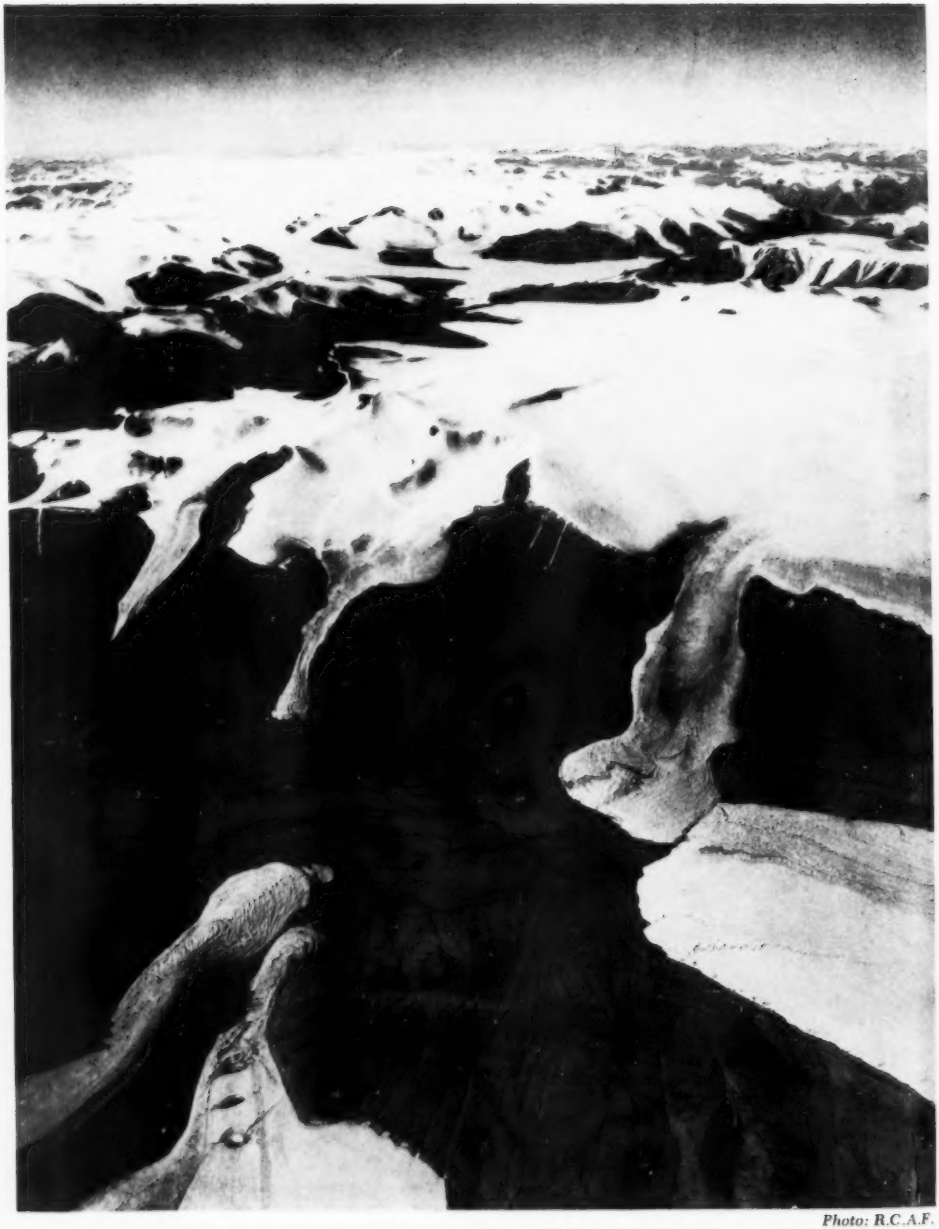

Photo: R.C.A.F.

Fig. 1. Small ice cap, Conger Range, Ellesmere Island. View looking west towards the United States Range.

THE ICE AGE IN THE NORTH AMERICAN ARCTIC

Richard Foster Flint*

Significance of glacial and interglacial ages

Arctic North America[1], in common with the rest of the world, is now emerging from the latest of the series of glacial ages which, as a group, have characterized the last million years or more of geological time. During the glacial ages, each of which was a hundred thousand years or more in length, the mean temperatures at the earth's surface were markedly lower than today. In consequence the proportion of snowfall to rainfall increased, melting diminished, and the accumulated snow formed glaciers. These great ice masses spread outward, slowly flowing under their own weight, until they covered one quarter to nearly one third of the land area of the world, principally of course in high and middle latitudes. In North America and Greenland alone, the area covered by ice amounted to seven million square miles.

Between the cold glacial ages, warmer times intervened. The record of the soils formed in temperate latitudes during the warmer, interglacial ages shows that those ages were longer than the glacial ages—one of them probably lasted 300,000 years. The record of the fossil animals and plants entombed in the deposits of interglacial times establishes that one or more of those times was warmer than today; from this the inference follows that the interglacial ages probably witnessed a more extensive disappearance of ice from the arctic regions than is now the case. In fact for the world as a whole the present is a time transitional from glacial to interglacial. The great ice sheets that formerly blanketed much of North America and Eurasia have disappeared, but more than ten per cent of the world's land area still remains covered by glacier ice.

The glacial and interglacial ages together constitute the Pleistocene epoch, the latest epoch in the scale of geological time. Although this epoch is also known as the "Ice Age", the latter term is not a good one; it is too simple. It does not imply that it includes the interglacial ages, whose combined length was greater than that of the combined glacial ages.

Most of the information on which we have formed our concepts of Pleistocene conditions comes from temperate regions. Knowledge of the

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[1]Throughout this paper "Arctic North America" is used in the broad sense and includes both arctic and subarctic regions.

former glaciation of arctic regions is scanty and is based in part on inferences from research carried on in lower latitudes. At present our reconstruction of glacial and interglacial events in the Arctic consists of broad generalizations, meagrely supported at one place or another by detailed data. As exploration and research fill in the wide blanks in our knowledge much will be learned that will modify our concepts concerning the extent of the former glaciers, their growth and decay, and the paths they made possible for large mammals and for early man emigrating from northeast Asia into North America.

Evidence of glaciation[1]

Today only a minor proportion of the arctic and subarctic regions is covered with glacier ice. But it is now well known that during the glacial ages a very large proportion of the land areas of these regions was overspread by glaciers, while the seas were largely covered with ice consisting of frozen sea water plus icebergs broken off from the glaciers along the coasts.

This knowledge is based on evidence of various kinds. Direct evidence of former sea ice is little known as yet, but it is unmistakable. In 1936 the Western Union Telegraph Company's ship *Lord Kelvin* made a cable-repairing voyage from Canada to Britain. On board was Dr. C. S. Piggot, who had invented a device for taking a 10-foot core sample of the soft sediments beneath the sea floor. A study of the series of cores he made from the region between Newfoundland and Ireland showed that the sea floor in that region is underlain by alternating layers of foraminiferal ooze and pebbly grit (Bradley and others, 1940). The single-celled foraminifera contained in the ooze are characteristic of the warm surface waters of the Gulf Stream. The pebbly grit likewise contains some foraminifera, but they are of types peculiar to colder northern waters.

There can be no reasonable doubt that the layers of pebbly grit were deposited by sea ice as it floated southward and melted during glacial times. The layers of foraminiferal ooze, on the other hand, were deposited under warmer conditions much like those of the present day. Hence there is firm ground for the belief that in the glacial ages the northern seas yielded sea ice that was far more abundant and that extended much farther south than at present.

On the lands of Arctic North America the glacial ages left a more evident impress. In the alpine mountains of British Columbia and Alaska in the west, and of Labrador, Baffin and Ellesmere islands, and Greenland in the east, the shattering action of frost, accompanying the glacial climates, sculptured typical jagged peaks and serrate ridges and, at slightly lower altitudes, excavated the capacious, half-bowl-like corries that characterize the heads of most glaciated valleys. The larger valleys were converted into fiords and, in Alaska and British Columbia, where the rate of flow of the glaciers was rapid owing to abundant snowfall, some valleys were deepened at least 2,000 feet by glacial erosion. Now partly filled with sea water, these trough-like valleys are the familiar fiords characteristic of the mountainous coastal regions of high latitudes.

[1]Systematically discussed in Flint, 1947.

Photo: R.C.A.F.

Fig. 2. Nearly bare glaciated bedrock, Rae Isthmus, Melville Peninsula. View looking west.

On the lowlands the slow grinding action of thick glaciers almost entirely removed the mantle of preglacial soil and subsoil, and grooved, scratched, polished, and generally smoothed the surface bedrock underneath. In places where the rock is cut by closely spaced fractures and other planes of weakness, the glaciers quarried out blocks of many sizes, creating roughened surfaces, as well as many rock basins that now contain lakes.

The depth of glacial erosion of the lowlands was small, as is indicated by the preservation of preglacial topographic features and of chemically altered bedrock that could only have been formed close to the surface during preglacial time. Most estimates place the layer of soil and rock removed by glacial action at a few tens of feet at most. The small figure is the result chiefly of the lowland character of the country; there were no deep valleys to channel and concentrate the flow of the ice, nor were there mountains to provide steep gradients.

Here and there throughout the lowland region, irregular deposits of earth and stones (the *glacial drift*) left on the surface, chiefly during the melting of

Photo: R.C.A.F.

Fig. 3. Drumlins. View looking east on Barren Grounds near Artillery Lake.

the glaciers, created obstructions to the natural drainage, forming many lakes in addition to those occupying bedrock basins.

The glacial drift is generally thin and is distributed in patches. In the regions surrounding Hudson Bay and lying immediately east of the Mackenzie Great Lakes, where the ancient bedrock is strong and not easily eroded, bare, ice-smoothed outcrops are much in evidence and drift is scanty. Farther west, in the plains region, where the weaker bedrock yields more readily to erosion the covering of drift is more general. It is also thick in the central region between Hudson Bay and the Mackenzie River.

Much of the drift is a variety of *till*—a tough, compact, nonstratified stony clay plastered bit by bit on to the ground from the load of rock fragments carried in the base of the slowly flowing glacier. The till is usually only a few feet in thickness, although in the plains region it may be much thicker. In some areas where the till is comparatively thick the flow of the overriding ice has molded it into the whaleback hills known as *drumlins*. Commonly these occur in broad groups, the individual drumlins ranging in length up to three miles. Thus far drumlins have been reported principally from the region

Photo: R.C.A.F.

Fig. 4. Esker on Barren Grounds between Back River and Contwoyto Lake.

west of Hudson Bay, as far west as northern Saskatchewan. Undoubtedly further exploration will bring to light many more than are now known. The value of drumlin study lies in the fact that the long axes of these hills record the general direction of flow of the glacier ice at the time when they were built.

The *esker*, another type of drift accumulation, is also useful in reconstructing the movements of glaciers. Eskers are long and usually winding ridges, several tens of feet in height, and in some cases more than one hundred miles in length. Some of them branch like streams, and all are built of stratified glacial sediments. They are believed to be the deposits made by streams of meltwater that flowed in tunnels beneath the ice or in channels in the surface of thin ice, in the marginal part of an ice sheet. They were built during the period of decay, just before the ice melted away, and are generally aligned at right angles to the trend of the glacier margin at the time they were built. Thus they may record successive positions of the edge of the ice sheet during its shrinkage. Eskers are numerous in Arctic North America, but as yet they have been mapped in two regions only: east of Great Slave and Great Bear lakes (Wilson, 1939, 1945) and in central Quebec and Labrador.

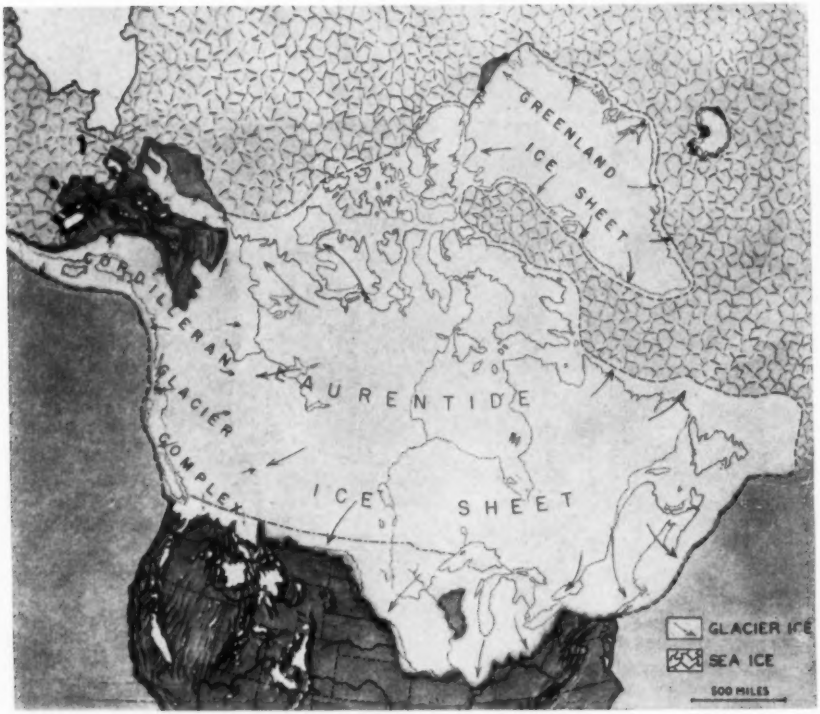

Fig. 5. Glaciated areas in North America, generalized to show the maximum area covered regardless of date of glaciation. (Reproduced by permission from 'Textbook of Geology', Part 1, by Longwell, Knopf, and Flint, published by John Wiley and Sons).

End moraines—ridges of drift heaped along the margin of the ice sheet—occur here and there. Except in a few localities, however, no systematic attempt has been made to map them. When fully mapped these features too, like the drumlins and eskers, will constitute a valuable clue to the successive positions of the retreating margin of the ice sheet.

Distribution and types of former glaciers

Figure 5, adapted from the Glacial Map of North America (Flint and others, 1945), shows the areas at present believed to have been covered by former glaciers in North America. Excepting in the region of the Arctic Ocean, the limits of the highland glaciated regions are fairly well known, though many details remain to be filled in. Of the vast lowland area west, north, and east of Hudson Bay, our knowledge is hardly even elementary.

The distribution and directions of flow recorded by the former glaciers show that the two great groups of highlands in Arctic North America—the western or Pacific and the eastern or Atlantic—were glaciated and that glaciers originated in these highlands. Data of the same kind show that the vast lowland region between these highland groups was also glaciated—evidently by

a thick and extensive ice sheet. It was long believed that this ice sheet was built up by the accumulation of fallen snow on the lowlands themselves. However, I have put forward reasons for believing that the great lowland ice sheet grew up through the coalescence and expansion of glaciers from the Atlantic highlands (Flint, 1943, 1947; Demorest, 1943). According to this view the ice sheet was in a sense an immigrant into the lowland country rather than being indigenous. The manner in which the ice sheet developed is not entirely settled, nor can it be until much more has been learned about the glacial geology of the vast region surrounding Hudson Bay. The discussion that follows is based on the view that the broad ice sheet invaded the lowland from the east, with the reservation that this view is not yet fully proved and is therefore subject to whatever modifications may be made necessary by further study.

The Cordilleran Glacier Complex. The Cordilleran or high-mountainous region of western North America, from Alaska to Mexico, is dotted with glaciers today. The colder climates of the glacial ages brought about so great an expansion of glaciers in this region that from southern Washington northwestward to the Bering Sea a complex of coalescent valley glaciers, piedmont glaciers, and ice sheets covered a combined area of more than 950,000 square miles[1]. On the west this ice entered the Pacific and probably formed a floating shelf similar to the shelf floating on the Ross Sea off the Antarctic Continent today. On the east the ice descended to the plains where, along a 1,700-mile front stretching from Glacier National Park in Montana to the mouth of the Mackenzie at the Arctic Ocean, it coalesced with the great lowland ice sheet.

The distribution of the Cordilleran glaciers was controlled then, as today, by two principal factors: high land and atmospheric moisture. These controls are clearly evident in Alaska. There the thickest and most extensive glaciers formed on the coastal mountains, which not only are the highest and most massive mountains in western North America but also stand directly in the path of warm moist air masses coming in from the Gulf of Alaska. The Brooks Range in northern Alaska is lower, less massive, and faces the cold Arctic Ocean rather than the warm Gulf of Alaska. In that range the glaciers were correspondingly less extensive, thinner, and less active. Between the coastal mountains and the Brooks Range the lowlands drained by the Yukon River had no glaciers at all; this intermontane country, although cold, was too low and too dry to support them.

In southern Yukon and northern British Columbia, where coastal mountains are lower, enough moisture was carried across the coastal barrier to build up a thick ice sheet in the rough but lower country between the Coast Ranges on the west and the Rocky Mountains on the east.

The Laurentide Ice Sheet. Most of North America east of the Rocky Mountains was overspread during the glacial ages by a vast, coalescent mass of ice to which the name Laurentide Ice Sheet has been given (G. M. Dawson, 1890,

[1]For descriptions of the glaciation of representative districts see Kerr, 1934; Capps, 1932.

p. 162)[1]. The area of this glacial carapace at its maximum probably exceeded five million square miles. Its exact eastern limits are not known because the ice extended to seaward of the present coast and the evidence is therefore submerged. To the north the vast glacier covered the southern and eastern islands of the Canadian Arctic Archipelago and overspread the network of narrow straits that separated them. Whether the most northerly and westerly islands were ever wholly buried beneath ice is not known, simply because the geology of much of the region has never been investigated.

The ice grew thick enough to overtop most or all of the highlands in northeastern North America, and may possibly have reached an extreme thickness of 10,000 feet, although this figure is a matter of conjecture.

Greenland Ice Sheet[2]. Eastward across Baffin Bay and Davis Strait the Greenland Ice Sheet, during the glacial ages, was thicker and more extensive than it is today, as is clearly shown by the ubiquitous signs of glaciation both vertically above and outward beyond the existing ice sheet. It can hardly be doubted that the Greenland and Laurentide ice bodies were firmly coalescent across the narrow straits that separate northwest Greenland from Ellesmere Island. It is even possible that the two ice sheets, partly aground and partly afloat, were coalescent across Baffin Bay and Davis Strait.

Despite its great area, the Greenland Ice Sheet failed to cover the extreme northeastern tip of Greenland, just as it fails to do today. The explanation lies in lack of nourishment. In that region the precipitation is now very small, and during the glacial ages it must have been as small or smaller, literally starving the northeastern tip of the Greenland Ice Sheet.

Growth and disappearance of the glaciers

The hypothesis that best fits the facts now known is that each of the glacial ages began with a world-wide gradual reduction of temperature. In consequence the proportion of snowfall to rainfall increased, and the melting of fallen snow during the summer diminished. All of this, quite understandably, resulted in the enlargement of glaciers existing in the higher mountains and in the appearance of many new glaciers in mountainous districts. There can be little doubt that in Arctic North America the first crop of glaciers took form in the two great mountain regions: the Alaska–Yukon region and the Greenland–Ellesmere Island–Baffin Island–Labrador–Quebec region.

The probable growth of the glaciers in the Alaska–Yukon region is not difficult to trace. Individual mountain glaciers enlarged, thickened, and coalesced. Many of them spread out beyond the bases of the mountains as piedmont glaciers. In southern Yukon and northern British Columbia the ice bodies flowing eastward from the Coast Ranges and those flowing westward from the Rocky Mountains coalesced over the rough but somewhat lower country between them, and the combined mass thickened and grew into an ice sheet that nearly overtopped the high mountains themselves. Geological

[1]For good descriptions of some of the glacial features see Bell, 1890; J. W. Dawson, 1893; Tanner, 1944, pp. 173–253.

[2]Systematically discussed in Kayser, 1928.

evidence shows clearly that the ice, when near its maximum extent, flowed from the lower interior country westward *across* the higher coastal mountains to the Pacific.

The growth of the glacier ice in the eastern part of the continent is less clearly evident, but the probable course of events was similar. Through the use of what scanty direct evidence we have, and by analogy with better-known regions, we can conjecture that on each of the highlands along the northeastern border of the continent proper, and in Greenland, the new crop of glaciers expanded until they coalesced, as did those in the far west. Recent seismic measurements on the Expéditions Polaires Françaises have suggested the possibility that the land mass of Greenland consists of three separate islands which have been buried beneath the Greenland Ice Sheet.

Glaciers descending the western slopes of the mountains of Ellesmere and Baffin islands, and of Labrador and Quebec, formed a piedmont apron of ice that chilled the air above it and thus drew snowfall from the comparatively moist air masses that approached it from the south and southwest. The added snowfall increased the thickness of the ice, which thereby gradually became a topographic barrier to the southerly and southwesterly winds, as well as a cold-air barrier or polar front. Snowfall was thereby still further increased, which in turn thickened the ice and increased its outward spread.

The high cold front of the combined glacier crept slowly westward and southward, fed by moisture brought to it by the winds it intercepted. At the same time the ice thickened until it buried, or nearly buried, the highlands along the northeast coast on which the earliest glaciers had formed. The ice, now the full-fledged Laurentide Ice Sheet, flowed across the broad shallow Hudson Bay depression and up the long gentle slope of the plains country to the west. Its uphill course was made possible by its great thickness. Ultimately it met the piedmont glaciers flowing eastward from the Rocky Mountains and merged with them to form a continuous glacial mantle that stretched from the Labrador Sea to the Gulf of Alaska, broken only by high mountain peaks. The line along which the two ice masses merged shifted its position from time to time, but it was never far east of the Rocky Mountain front. This line lay along the general course of the Mackenzie and Liard rivers, through the vicinities of Fort Nelson and Dawson Creek, and passed west of Calgary and Lethbridge, to the southern limit of the ice at the International Boundary. That rock debris was brought to this line by both glaciers is shown by exposures of overlapping glacial deposits, one layer containing Rocky Mountain stones, another containing stones brought from the region west of Hudson Bay, and still another layer containing a mixture of both.

The transport of stones to western Alberta from the country immediately west of Hudson Bay involved not only a journey of many hundreds of miles but also a vertical lift amounting to more than 4,000 feet. In order to accomplish the lift, the ice sheet must have had a thickness considerably in excess of this value. It is not probable, however, that the ice sheet, when at its maximum, was thickest at its geographical centre and thinner elsewhere. The probability is that the ice was thickest at its eastern and southern marginal

areas—the areas that intercepted the largest amounts of atmospheric moisture—and that elsewhere the ice was thinner. The glacial striations and other geologic evidence of direction of flow of the ice are still too scanty to justify definite conclusions, but such facts as we have are consistent with this concept.

If this was the case, then the flow of the spreading ice was most active in the southern peripheral zone and was least active in the vast interior and northern areas. Furthermore, most of the ice markings left on the bedrock and the localized accumulations of glacial drift deposited on the surface must have been made during the waning of the ice sheet; for the majority of the markings and accumulations made earlier would have been erased or reshaped by later movement.

Floating shelves of glacier ice, like the shelf off northern Ellesmere Island today, undoubtedly fringed many coasts. Beyond the shelves the sea ice was far more extensive and more nearly continuous than it is today. Pack ice filled not only the Arctic Ocean but also the Bering Sea and the Greenland and Labrador seas, and reached into the North Atlantic beyond the southern coasts of Greenland and Iceland.

The state of exploration of Arctic North America permits us as yet to sketch only the general outlines of the deglaciation—the shrinkage of the glaciers from their former great extent. As recorded by a variety of features, chiefly in the glacial drift, the shrinkage seems to have been generally concentric, inward toward a "last stand" of the shrunken main body of the ice sheet in the regions of Hudson Bay and the Quebec–Labrador highlands. But wherever there were conspicuous highlands their cold and moist climates favoured the persistence of glacier ice upon them. Thus southeastern Quebec, Labrador, and Baffin and Ellesmere islands and their high-standing neighbours, as well as Greenland, continued to nourish glaciers of various kinds separate from the main residual ice body. Some of these separate glaciers, notably the Greenland Ice Sheet, persist today despite a somewhat unfavourable climate and conspicuous contemporary shrinkage.

Evidence of repeated glacial ages

Most of the evidence that glaciation was repeated comes from the temperate region, where the southern margins of the great glaciers piled up at least four overlapping layers of drift, each separated from the one below it by a zone of deep weathering-decomposition that indicates a lapse of perhaps hundreds of thousands of years. During each glacial age most of the arctic region lay beneath ice, and in the mountainous areas the intensity of glacial erosion favoured the destruction of earlier-formed drifts. Hence, as yet, the Arctic has contributed little to our growing knowledge of the succession of glacial ages. In no arctic locality has clear evidence of more than two glacial ages yet come to light. If the Arctic alone were considered, this fact might be taken to mean that glaciers continued to cover much of the arctic region during the interglacial ages proved to exist in lower latitudes. But when the whole glaciated region is examined, such a condition is seen to be very improbable, for the fossil plants and animals contained in some of the inter-

glacial deposits imply arctic climates as warm as, or warmer than, those of today. This in turn implies very widespread deglaciation.

Within the arctic region perhaps the best evidence of repeated glaciation is a series of exposures in the district south and west of James Bay (McLearn, 1927, pp. 30C–31C). Here, between two sheets of till, is a layer of peat, the compressed remains of a spruce–pine–birch–fir forest. Clearly there were two glaciations of this district and, although the length of the intervening time is not evident, it is probable that both glaciations are of very late date.

In the Carmacks district, Yukon, there are present two till sheets of which the younger contains firm, fresh stones while the stones in the older are thoroughly decomposed. A long interglacial process of soil formation is indicated (Bostock, 1936, p. 48).

In the sea cliffs of Herschel Island, in the Beaufort Sea west of the mouth of the Mackenzie River, extensive beds of soil and clay containing twigs and at least one log are exposed (O'Neill, 1924, p. 12). Again, near the mouth of the Ikpikpuk River, on the arctic coast of Alaska east of Point Barrow, spruce logs occur in the sediments of the coastal plain (Smith and Mertie, 1930, p. 254). Large logs are found in the superficial deposits of the Kuzitrin lowland north of Nome, Alaska (Collier and others, 1908, pp. 89, 91). Little is known about these deposits but, as their localities lie beyond the present poleward limit of trees, the material may be interglacial. We cannot state the inference more strongly than this, because the possibility that the twigs and logs were simply driftwood, perhaps from distant points of origin, has not been eliminated.

There is clear evidence of at least two glacial ages in the frozen ground in the Yukon River basin in central Alaska, although the region was never glaciated because it is low, dry, and subject to warm summers. This country is underlain by thick beds of silt, deposited mainly by the Yukon and other rivers. As it lies within the arctic belt of perennially frozen ground, most of the silt is frozen to depths reaching hundreds of feet. Mining operations have exposed extensive sections of the silt, overlain by thick mudflow deposits consisting of thawed silt, now refrozen. Such sections furnish evidence of an episode of deep thaw that intervened between two episodes of deep freezing (Taber, 1943). As freezing and thawing well below the surface take place slowly, a long interval of warmth is indicated. These events, however, have not yet been firmly dated.

In northern British Columbia and also on the east coast of Greenland the forms of major valleys seem to indicate a period of deep stream trenching that occurred between two periods of glaciation.

These are the scattered pieces of evidence of repeated glaciation derived from the arctic region. Many more will be discovered, but they are not likely to approach either in quantity or quality the records from the southern margin of the glaciated region.

A great variety of evidence has established the belief that since the latest of the glacial ages reached its peak several tens of thousands of years ago and began to wane, the climate has not become continuously milder. The record shows that in northern Europe and temperate North America, at least, climates

attained a maximum of warmth and dryness roughly 5,000 years ago; since when, conditions have become appreciably cooler and wetter. It has been shown that some of the glaciers in western United States had dwindled away or disappeared entirely during the period of warmth and were later reborn. Arctic America is not likely to have undergone so drastic a change because of its cooler climate, but nevertheless it is likely that all the arctic glaciers underwent at least some reduction in size during the warm period. Future research is likely to bring forth evidence that this reduction occurred.

Glacial lakes

The great deglaciation that has been in very irregular progress throughout the last few tens of thousands of years was accompanied by the appearance of many temporary lakes, held in between glacier ice on one side and sloping ground on the other. Most of the lakes were localized in preglacial stream valleys, depressions that could be converted into basins by glacial erosion, or damming by ice, or both. Some of the most conspicuous preglacial valleys had developed along the contact between the igneous and metamorphic Precambrian rocks of the Canadian Shield and the surrounding Paleozoic sedimentary rocks. Major lakes of today, such as Great Bear and Great Slave lakes and Lake Winnipeg, consist of segments of these valleys converted into lake basins by glacial action. These, together with other lakes in the region west of Hudson Bay (notably Lake Athabaska and Wollaston, Reindeer, Cree, and Lesser Slave lakes), show by the abundance of lake deposits and abandoned strandlines in the terrain surrounding them that they were considerably larger during the shrinkage of the ice sheet than they are at present.

The two larger lakes formed partly within the arctic region during the deglaciation have almost entirely disappeared. *Lake Agassiz* extended from latitude 46°N., in Minnesota, nearly to latitude 58°N., in northern Manitoba, and had an area equal to that of the existing Great Lakes combined. It was held in the north and east by the edge of the ice sheet, and when this melted away the water drained off to Hudson Bay, leaving a few basins, lakes Winnipeg and Winnipegosis, to contain residual pools. *Lake Ojibway-Barlow*, south of James Bay, was held in in the same manner. It stretched from the 76th meridian to the 88th, and when glacial melting destroyed its northern shore it drained away, leaving upon the bedrock surface a veneer of silt and clay to mark its former extent. This is the well known "clay belt" which has made a wide region possible for agriculture, in contrast with the rocky country surrounding it.

The postglacial sea and rise of the land

The greater part of the coastline of Arctic North America is fringed with superficial deposits of sand and silt, in places containing the fossil shells and bones of marine animals. Throughout great distances these deposits are fashioned into beaches, bars, and other shore features sweeping along the contour of gently sloping terrain. Shore and sea-floor deposits of this kind form a discontinuous belt that varies greatly in width. Along steep coasts,

Photo: R.C.A.F.

Fig. 6. Successive shorelines lifted above sea level by upwarping accompanying deglaciation. West coast of Hudson Bay at mouth of Shell Brook, south of Fort Severn.

such as those of Labrador and British Columbia, the deposits are narrow and very discontinuous, consisting of hardly more than local patches. Along gently sloping coasts, such as the coast of Hudson Bay, they increase to form a belt more than 150 miles wide, and in the Thelon River basin, northwest of Hudson Bay, the width of the belt exceeds 400 miles. The greatest height of the marine features above present sea level likewise varies from one part of the coast to another. This height commonly reaches 500 feet; and, at a few points, it has been observed to reach as much as 900 feet. In contrast, in northwestern Alaska it is not certain that marine deposits extend above the present level of the sea. In general the height increases with increasing proximity to the Hudson Bay region, which lies near the geographical centre of the area covered by the former ice sheet.

In the few places where exposed sections of these deposits have been examined, they are seen to rest upon the glacial drift. Hence the marine sediments postdate the glaciation. The phenomenon of marine deposits overlying glacial drift is known also in southeastern Canada and New England, and is still better known along the Baltic Sea coasts of Sweden and Finland. The explanation now widely accepted is that the weight of an ice sheet causes the earth's crust beneath it to subside slowly. As the great glacier

shrinks, the sea inundates the subsided crust, which is slowly rising (though with a considerable time lag) owing to reduction of the glacial load. At first the sea rests against shores of glacier ice. But as the ice sheet shrinks and as the crust rises, the shoreline is transferred to the ground vacated by the ice and is forced to retreat little by little. Thus are explained the marine cover and the successive shorelines at ever-decreasing levels. Evidently, then, during an earlier phase of the process of postglacial uplift, Hudson Bay was very much larger than it is now.

There are indications of various kinds that the upheaval is still in progress. Prominent among these are the occurrence at several localities of Eskimo dwellings, built near the shoreline, and fish traps, built between high and low tide, now 30 to 80 feet above sea level (cf. Bell, 1884, p. 37; Washburn, 1947, pp. 69–71). Calculations based on the probable amount of depression of the crust under the ice sheet, and on the uplift already accomplished, indicate that in the region of Hudson Bay some additional hundreds of feet of uplift are to be expected before the crustal equilibrium that prevailed before glaciation will have been restored. From this it follows that Hudson Bay will gradually become still smaller. In fact it is probable that by the time the movement has ended, the Bay will have become once more a broad plain drained by a master stream flowing north. There is reason to believe that in preglacial time this master stream included the drainage of the Missouri River in North Dakota and Montana, but that that drainage was diverted toward the south by the expanding ice sheet.

The absence of highly elevated marine features from the western and northern coasts of Alaska results probably from the fact that western and northern Alaska were but scantily covered with ice, so that disturbance of crustal equilibrium there was small. Postglacial emergence of the Pacific coast of Alaska and British Columbia has been conspicuous; this is in keeping with the known thick cover of glacier ice in that coastal region.

Chronology and causes of glaciation

The North American Arctic yields very little direct information either on the actual dates of events in the glacial past or on the probable causes of the glacial climates. Our knowledge of these matters, still very scanty at best, comes chiefly from the glacial drift sheets in the temperate zones of North America and Europe. Until the use of the radiocarbon method of dating, developed by Libby (1952), it was assumed that the time elapsed since the shrinking ice sheet began to uncover the very young Mankato drift was 25,000 years. Radiocarbon measurements of wood from the Two Creeks peat, immediately underlying the Mankato drift, has shown that the age of the wood is only about 11,000 years (Flint and Deevey, 1951). As yet the radiocarbon method is directly applicable only to organic matter less than 30,000 years old. Therefore the degree of chemical alteration of each of the several drift sheets still furnishes the best chronology, inaccurate though it is. At present the lengths of the glacial ages can only be guessed at, but they are widely regarded as having been much shorter than the interglacial

ages. The whole group of four glacial and three interglacial ages together is believed to have lasted roughly one million years.

Because the interglacial times are believed to have been longer than the glacial times, the Arctic has been largely free of a glacier-ice covering during the greater part of the Pleistocene epoch. However, whatever thin soils may have been developed over the surface of the bedrock during the ice-free interglacial ages were almost wholly swept away by the intervening glaciations.

The fluctuations in the mean annual temperatures of temperate latitudes during the Pleistocene epoch seem to have been no more than 10°C—roughly 8° colder than now during the glacial ages and 2° warmer than now during the interglacial ages. The causes of these repeated fluctuations constitute a much-debated question to which various answers have been given. To me the cause appears to have been twofold (Flint, 1947). The first factor was a conspicuous world-wide elevation of the lands in general and of many mountain ranges in particular, during the epoch immediately preceding the Pleistocene and continuing into the Pleistocene epoch itself. This elevation in itself reduced surface temperatures in several ways, though alone it cannot explain repeated temperature fluctuation. The second factor is an assumed fluctuation in the rate at which radiant energy is emitted by the sun. Small present-day fluctuations are currently observed, but the larger fluctuations necessary to form glaciers on the highlands must be assumed. These two factors constitute a reasonable and, it seems, probable explanation of the glacial and interglacial ages, though the second factor is not at present capable of proof.

Effect of glaciation on life

The present-day flora of the North American Arctic includes few endemic forms. There can be little doubt that glacial-age conditions in the glaciated regions almost wholly extinguished the plant cover, which was renewed after each glacial age by immigration from the nonglaciated territory. Probably the principal arctic refuge within which plants with sufficient hardihood survived the glacial ages lay in nonglaciated areas in central Alaska and the adjacent parts of the Yukon. In addition, repopulation of the arctic flora must have taken place to a considerable extent from the belt of country lying south of the southern limits of glaciation.

If, during the glacial times, there was a conspicuous belt of tundra at the southern margin of the ice sheet, there is little evidence of its former presence. Most of the comparatively few exposures of plant-bearing deposits immediately overlying the drift sheets yield floras, dominated by spruce and fir, such as characterize the subarctic forest of the present day. It seems likely, therefore, that the subarctic forest generally reached close to the margin of the ice sheet and that the intervening belt of tundra was narrow. Along the arctic coast between Point Barrow and the Mackenzie River, as already noted, there are suggestions of tree growth, presumably during some interglacial time (unless the wood in question is merely driftwood).

Evidence of the effect of the glacial ages on animal life in the far north is very slight, chiefly because there has been little systematic search for fossils.

We can be quite sure that in the glacier-covered areas animal life was completely extinguished. The change was gradual, and took place through slow migration, generally towards the south, as each glacial age developed. During the interglacial ages the glaciated tracts were repopulated with at least some of their former inhabitants. In the arctic regions, as elsewhere, the Pleistocene record is one of repeated wholesale shifts of faunal assemblages rather than one of conspicuous evolutionary changes in the animals themselves. On the other hand, cold-climate adaptations did appear in such Pleistocene mammals as the woolly mammoth and the muskox—adaptations that are unknown in the fauna of the preceding Pliocene epoch.

The only extensive Pleistocene mammal fauna thus far collected in Arctic North America comes from the nonglaciated interior region of Alaska and western Yukon. Here, in frozen muck and silt, has been found a rich collection (Frick, 1930; Stock, 1942; Quackenbush, 1908), that includes mammal types both extinct and still living. Among the extinct forms are the short-face bear (*Arctotherium yukonensis*), dire wolf (*Aenocyon dirus*), great cat (*Panthera atrox*), ground sloths (*Megalonyx* and *Nothrotherium*), camel (*Camelops*), great bison (*Bison crassicornis*), oviboids (*Symbos tyrrelli* and *Boötherium sargenti*), horse (*Equus alaskae*), woolly mammoth (*Mammonteus primigenius*), and mastodon (*Mammut americanum*). Forms still living include lion, peccary, reindeer, moose, bighorn sheep, saiga antelope, Rocky Mountain goat, and the muskox. The deposits from which the bones are taken have been thought to be of interglacial age, but the assemblage of fossil animals implies such different habitats that both glacial and interglacial faunas are suggested. The ground sloths, peccary, camel, and lion suggest a warmer climate than do the woolly mammoth, muskox, and reindeer[1]. More extensive study of the deposits may reveal that they are of more than one Pleistocene date.

Elephant bones and ivory are widespread in northwestern Alaska, together with fossil horse, muskox, and beaver (Smith and Mertie, 1930, p. 252). Fossil elephant remains, not generically identified, have been found in the Aleutian and Pribilof islands (G. M. Dawson, 1894; Bell, 1898, p. 374). Teeth ascribed to the Columbian elephant have been found near Edmonton and on an island in James Bay (Bell, 1898, pp. 370, 372). Mastodon bones have been collected from the Moose River near Moose Factory on James Bay and from the district west of Lake Winnipegosis (Bell, 1898, pp. 383, 387; Hay, 1923, p. 166). Fossil muskox, reindeer, and seal occur in the younger deposits of Ellesmere Island (Hay, 1923, p. 244).

These scattered bits of information hardly provide a firm basis for reconstructing a picture of the arctic plants and animals of the various Pleistocene ages. All we can say with probability is that during the glacial ages the transition zone between tundra and subarctic forest was pushed far south of the Great Lakes region and that during interglacial ages it reached

[1]Even the Columbian elephant (*Mammuthus columbi*) has been reported from Alaska (Bell, 1898, p. 371). If correctly identified, this form would suggest a warmer-than-glacial climate.

somewhat farther north than it does at present. This particular zone is recorded not only by fossil plants but by the distribution of the woolly mammoth, outstandingly an inhabitant of this zone. The various muskoxen generally preferred the open tundra; in contrast, the mastodon and moose inhabited the subarctic forest.

It is well known that many of the large mammals that inhabited northern North America during Pleistocene ages were immigrants from northern Asia via the Bering Strait bridge. The strait is both narrow and shallow. It could have become land at one or more times as a result of a moderate lowering of sea level, such as is known to have occurred during each glacial age when water was abstracted from the sea to build the great terrestrial glaciers. A slight warping of the earth's crust in the Alaska–Siberia region could also have converted this shallow strait into land. However the land bridge may have been made, there is little doubt that it existed and that over it moved a varied fauna into Arctic North America. The arctic region therefore was the corridor through which Asiatic mammals entered the New World.

In contrast with mammals on the lands, the vertebrate life in North American Arctic waters does not seem to have undergone conspicuous changes, probably because temperatures were fairly low during the interglacial as well as the glacial ages. The chief differences thus far noted consist of slight changes in postglacial faunal assemblages. These changes are attributable to increased salinity of the sea water, as dilution with glacial meltwater diminished, and to decreased depth, as continuing crustal uplift elevated the sea floors (Richards, 1937).

Among the mammals that crossed from Asia into North America via the Bering Strait bridge was man. He came in several, perhaps many, groups, over a considerable period of time. Very likely he followed some of the migrating game animals as a hunter.

Just where, or through how long a time, the diffusion of people from Asia into Arctic North America took place, is not known. It has been established that man was well settled in southern North America at the time when the Mankato expansion of the Laurentide Ice Sheet reached its maximum, roughly 10,000 years ago. But how long he had been there is still a question. When that question is answered, and when the climatic and ecological circumstances of the whole immigration become known, the arctic region will undoubtedly assume a new and important perspective in the history of man in America.

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Photo: Ramsey and Muspratt

THE SCOTT POLAR RESEARCH INSTITUTE

G. C. L. Bertram*

Just forty years have passed since Captain Robert Falcon Scott and his four companions died while returning from the South Pole. The journey and end of these men is a story which has probably stirred Britons more than any other peacetime event in centuries. They rallied nobly to Scott's last appeal to "see that those who are dependent on us are properly provided for", and the Captain Scott Memorial Mansion House Fund soon reached a total of £76,500 for disposal by its trustees.

When the Mansion House Fund had fulfilled its dual task of providing for dependents and of publishing the scientific reports, there still remained a sum of £13,000 set aside as a "Polar Research Fund". It was at this time, in the early 'twenties, that Frank Debenham, later Professor of Geography in the University of Cambridge, put forward proposals which sprang from discussions towards the end of 1912 with two other members of the Antarctic Expedition: Raymond Priestley, until recently Vice-Chancellor of Birmingham University, and Charles Wright, who later became Chief of the Royal Naval Scientific Service. Debenham showed convincingly that often the hard-won experience of polar expeditions in the past had been lost when their members dispersed, and that the techniques of life and travel in cold regions had been inadequately

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recorded. Each expedition had had to learn these techniques anew, rarely profiting from the experience of others, and in this way valuable time and even lives had been lost. To ensure that future expeditions might fully profit from the lessons of their predecessors, and that techniques might develop upon the sure basis of recorded experience, Debenham proposed the foundation of a centre or institute for polar research. It was at once recognized that a foundation of this nature, which would preserve continuity in research rather than give spasmodic help to expeditions, would admirably conform to the aspirations, both national and scientific, which Scott and other members of the expedition held so firmly.

In November 1920 the Council of the Senate of Cambridge University gave formal approval to the proposal to establish a polar research institute in Cambridge, and the institute found its first home in an attic room in the Sedgwick Museum of Geology. Finally, in 1925, the Trustees of the Captain Scott Memorial Research Trust transferred the Trust to the Chancellor, Masters, and Scholars of the University of Cambridge for the erection, endowment, and maintenance of an institute which might serve both as a memorial to the Polar Party and as a centre for the study of the polar regions. So the Scott Polar Research Institute was established. A Committee of Management was appointed by the Senate of the University, and Professor Debenham became the first Director, a post which he held with great distinction until 1946.

In the 'twenties and even more in the 'thirties there was intense interest in arctic exploration among undergraduates of Oxford and Cambridge, stimulated first by the leadership of George Binney at Oxford and James Wordie at Cambridge, then by Priestley's lectures in Cambridge and Debenham's enthusiasm as director of the youthful Institute. Much voluntary help was available. Books, maps, equipment, and records were amassed, and in 1927 the Institute moved from the Sedgwick Museum to Lensfield House, where a museum and library were formed. Public appreciation of the Institute rapidly developed and the need for a permanent building became obvious. The Pilgrim Trust therefore generously enlarged that portion of the original endowment which could properly be set aside for building, and in 1934, before a distinguished company of scientists and explorers from many different countries, Mr. Baldwin, Prime Minister and Chancellor of Cambridge University, opened the new building.

In its memorial and symbolic aspect the design by Sir Herbert Baker was much influenced by the late Dr. Hugh Robert Mill. Built of pale primrose brick with stone facings, the building is surmounted by a roof balustrade bearing the inscription *Qaesivit arcana Poli videt Dei* ("He sought the secrets of the Pole, he now sees those of God"). A bust of Captain Scott, modelled by his widow, Lady Kennet, is set over the main entrance. This entrance leads into a vestibule, on both sides of which the ceiling rises to a shallow dome. These domes each contain a coloured diagrammatic map by Macdonald Gill, one depicting the arctic and the other the antarctic regions, encircled by names of leading explorers of all nations who mapped those parts of the polar regions opposite their names. The marble floor below is set with stars in

Photo: Ramsey and Muspratt

The museum, showing the Eskimo and Lapp exhibits. The sledge and cooker are relics of Captain Scott's last expedition.

Photo: Ramsey and Muspratt

The library.

the form of the polar constellations, the Great Bear and the Southern Cross. The hall contains relics of Scott's last expedition including some of his final letters, Wilson's prayer book, Oates's sleeping-bag, and other articles brought back from the tent in which the Polar Party died. The vestibule leads into the museum hall, the contents of which are arranged to teach, by means of evolutionary series, the development of particular items of equipment, and to draw attention to current activities in the polar regions. There is also a section illustrating Eskimo and Lapp clothing and equipment, and examples of native art and culture. In addition to the museum there is a picture gallery, on the top floor of the building, where Dr. Wilson's water-colour sketches and drawings, of which there are more than 700 in the Institute's collection, are exhibited.

The collection of books, periodicals, scientific reports, photographs, and maps rapidly expanded and the Second World War demonstrated the value of the Scott Polar Research Institute as the repository of geographical, historical, and technical material not readily available elsewhere. The Institute provides facilities for research workers to prepare their reports, and a small staff gives help to enquirers. Although the Institute undertakes no formal teaching activities within the University, lectures are given during term by persons engaged in polar work of many different kinds. The *Polar Record* has been issued twice a year since 1931 to report on current activities and to record developments in technique and research in the arctic and antarctic regions.

The Institute's post-war growth in size and responsibility has been impressive, at first under the directorship from 1946–9 of the Reverend Launcelot Fleming, formerly chaplain and geologist of the British Graham Land Expedition of 1934–7. When Fleming became Bishop of Portsmouth he was succeeded by the present director, Dr. Colin Bertram, formerly zoologist of the British Graham Land Expedition.

The Institute is supported financially by the original endowment remaining from the Lord Mayor's Fund, by the subscriptions of the Association known as the "Friends of the Polar Institute", by the contribution of the Dominion Governments and their Agencies, but mainly by the British Treasury, whose interest since the Second World War has demonstrated the country's realization of its polar commitments and its need for specialist knowledge.

Thus the tragedy of forty years ago is commemorated by a growing Institute and an ever-increasing fund of knowledge on the polar regions.

HYDATID DISEASE IN BOREAL REGIONS

Robert Rausch*

HYDATID disease, or echinococcosis, is one of the more important helminthic diseases which may be transmitted from lower mammals to man. It is caused by tapeworms of the genus *Echinococcus* (Rudolphi, 1810), which are cosmopolitan in their distribution. A serious threat to human health exists wherever there is contact between man and infected carnivores.

It is the purpose of this paper to review the status of hydatid disease in the boreal regions of the world. Its importance has long been recognized in Eurasian countries, but only during recent years have investigators added anything significant to the knowledge of hydatid disease in North America. There is need to disseminate up-to-date information among medical workers in Canada and Alaska, where the disease is endemic in northern regions having a large aboriginal population. Therefore, particular emphasis will be placed on the situation in boreal North America.

Hydatid disease is defined as the infection of man by the larval stage of *Echinococcus granulosus* (Batsch, 1786). However, six species of *Echinococcus* are currently considered valid, and all may be capable of infecting man. The taxonomy of tapeworms of this genus is based on morphological characters of the adult stage. There is reason to believe that other factors should be considered, and that normal variation in the structure of the adult worm should be investigated in order to have a better concept of what constitutes specific differences.

In the northern hemisphere, so far as I am aware, only two species exist. The common species is *E. granulosus*, but it is apparent that another, at least immunologically distinct, species also occurs in Siberia and on St. Lawrence Island in the Bering Sea.

The life cycle of the various species of *Echinococcus* is a simple one, involving but two hosts: the final host, which harbours the adult parasite, and the intermediate host, which harbours the larval stage (Fig. 1). The adult parasite occurs in the small intestine of carnivores, and ordinarily is very numerous. Canine animals are the only important final host-group, but in some parts of the world feline animals are also included (namely, lion, puma, and jaguarundi cat). Ungulates are the main intermediate host-group though a few other mammals, including man, may be infected. For the species of *Echinococcus* found in Siberia and on St. Lawrence Island voles of the genera *Microtus* and *Clethrionomys* serve as the intermediate host.

The adult parasite is remarkably small when the size of the larval stage is considered. Alaskan specimens collected from dogs, wolves, and red and

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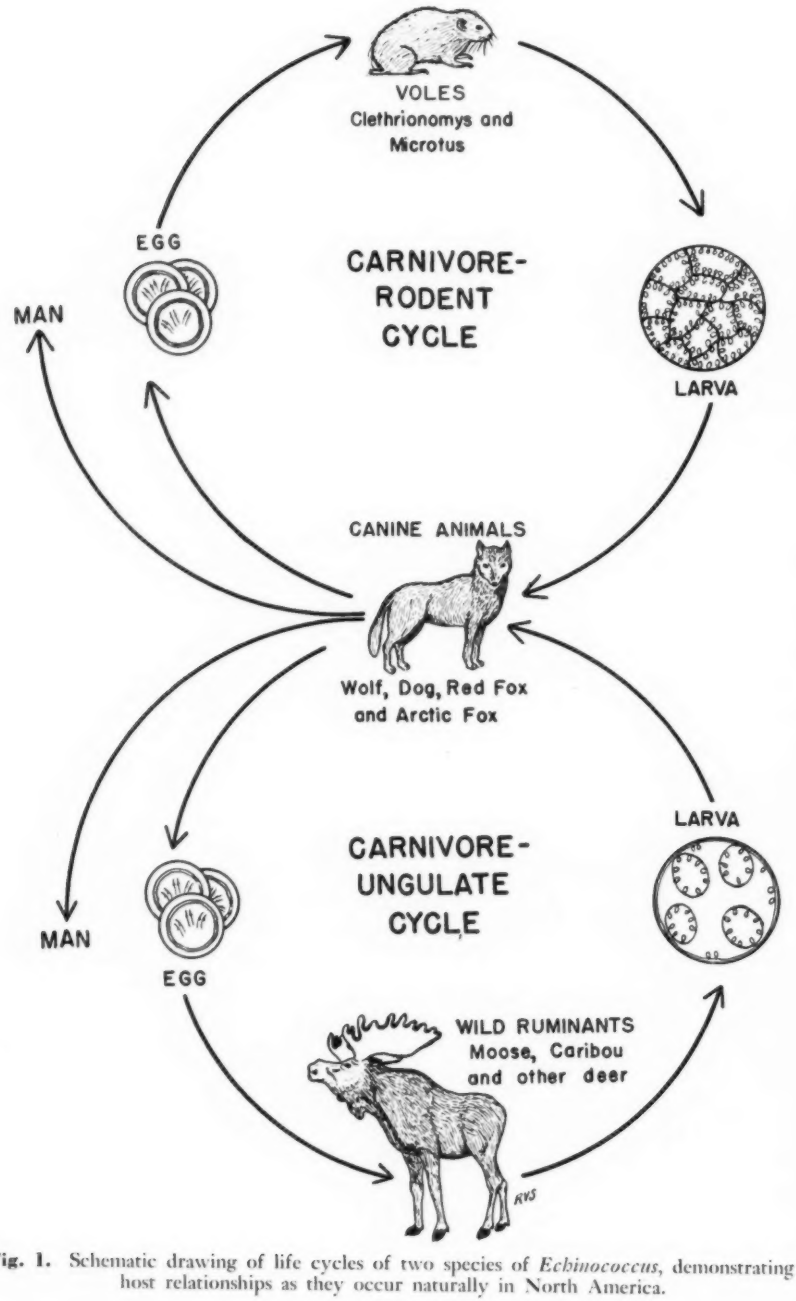

Fig. 1. Schematic drawing of life cycles of two species of *Echinococcus*, demonstrating host relationships as they occur naturally in North America.

arctic foxes measure in length from one to four mm. (Rausch, 1952). The strobila, or body, of the parasite consists of a scolex and three to four segments (Fig. 2). The scolex is provided with four suckers and an eversible rostellum

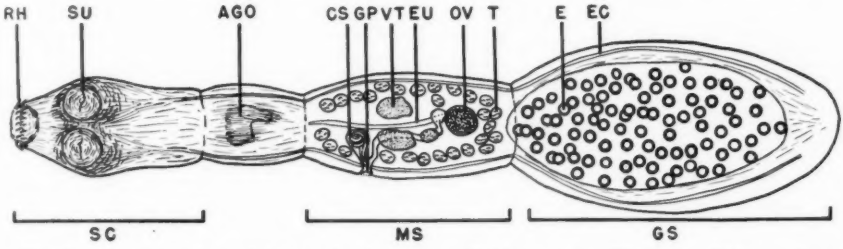

Fig. 2. Anatomy of an adult cestode of the genus *Echinococcus*. SC, scolex; RH, rostellar hooks; SU, sucker; AGO, *Anlagen* of genital organs; MS, mature segment; CS, cirrus sac; GP, genital pore; VT, vitelline gland; EU, early uterus; OV, ovary; T, testis; GS, gravid segment; E, egg; EC, excretory canal. Specimen from arctic fox experimentally infected with material of St. Lawrence Island origin. Magnification approximately 60X; original specimen 2.06 mm. long.

armed with a double row of hooks (about 30 in number) by which the strobila attaches itself to the host intestine. The first one or two segments following the scolex are not well differentiated, but contain rapidly-developing reproductive organs. The next segment contains mature (both male and female) reproductive organs. The terminal segment contains only a gravid uterus. Because of the great capacity of the larval worm for asexual reproduction, very heavy infections in the final host are usual; in some cases the cestodes cover nearly the entire mucosal surface of the host intestine (Figs. 3–4).

Egg production begins a few weeks after the ingestion of the larval stage by the final host. As the terminal segments become gravid, they are shed and eliminated in the feces of the host. The segment then disintegrates rapidly, freeing the eggs. There is some disagreement as to the minimum time required before the eggs appear in the excreta of the host animal. Fiebiger (1947) considered 70 days the minimum time. Mönnig (1938) stated that the worms mature in six to seven weeks. According to observations made in the laboratory of the Arctic Health Research Center, eggs may appear in the feces of experimentally-infected arctic foxes in about four weeks (St. Lawrence Island form of *Echinococcus*). Since each gravid segment contains roughly 200 eggs, it is evident that animals with heavy infections daily eliminate great numbers of eggs. These eggs are the source of infection for the various intermediate-host species, of which man is one.

Each egg contains an onchosphere, or embryo, possessing six hooks. When the eggs are ingested by a mammal capable of serving as the intermediate host, the egg shell is ruptured by the digestive processes. The liberated onchosphere then perforates the intestinal wall and enters the blood stream.

Because of the arrangement of the visceral circulation, the onchospheres are carried to the liver first. In man 60 to 75 per cent localize in this organ,

but few or none are found in the liver of some of the other intermediate hosts. However, in voles infected with the St. Lawrence Island larvae I have not so far seen localization in any organ other than the liver. If the onchospheres succeed in passing through the liver, they are carried into the right auricle of the heart, and thence into the right ventricle from which they pass to the lungs. In wild ungulates nearly all larvae are found in the lungs; in man less than 20 per cent localize in this organ. Any onchospheres which pass through the lungs and return to the heart, go into the systemic circulation from the left ventricle. These are relatively few, but in man they account for the larvae occurring in the brain, bone marrow, kidney, and elsewhere.

After the onchosphere of *E. granulosus* localizes in a given organ, growth takes place rapidly. Initial development gives rise to a solid mass in which a central cavity soon appears. A germinal membrane is produced, which lines the entire cavity. This membrane is in direct contact with a thin connective tissue capsule separating it from normal host tissue. The connective tissue wall is a product of the host tissue-reaction. The vesicle-like larva, commonly known as the hydatid cyst, is turgid and is filled with a whitish, rather opalescent fluid. The larva grows steadily and scolices are produced in great numbers by the germinal membrane. Secondary germinal vesicles may arise inside the first, and these also produce scolices asexually. Dew (1925) gives an excellent discussion of larval development. In man the larvae may reach a great size, for example, Dungal (1946) described a larval vesicle attached to the liver of an Icelandic woman which was 50 cm. in diameter and contained 16 litres of fluid.

The pathogenicity of *Echinococcus* infection involving *E. granulosus* is directly related to the locus of larval development in the body of the intermediate host. In the liver larvae may remain undiagnosed until accidentally discovered at autopsy since they commonly do not give rise to any clinical symptoms unless they become exceedingly large or unless they rupture; in the latter case larval growth in the peritoneal cavity may be extensive. Larvae in the lungs may not cause any recognizable effect. If, as sometimes happens, they rupture into a bronchus, recovery may be spontaneous, but more often complications arise. Hydatid disease elsewhere, such as in the kidney or spleen, is generally serious. In the brain the symptoms may resemble those caused by a fibrous tumour. Seizures and paralysis may occur, and there may be osteoporosis of the skull bones. If larvae reach the bone marrow, their growth causes gradual bone destruction and eventual pathological fracture; in many cases these fractures never heal. Localization in the myocardium may result in cardiac rupture. Spontaneous or traumatic (including surgical) rupture of the larva, wherever localized, may cause severe anaphylactic shock which in some cases results in death.

The literature on hydatid disease contains many references on pathogenicity, so it is necessary here only to mention that, in addition to the direct effects caused by the growth of the larva in the various organs, other indirect changes may occur. For instance, if the fluid contained in the larval vesicle escapes in small quantities various allergic reactions may follow; these may

Fig. 3. Adult cestodes *in situ* in the intestine of a dog experimentally infected with larval material from an Alaskan moose. Photographed at magnification of 4.5X.

Fig. 4. Histological section of gross specimen shown in Fig. 3. Considerable damage to the intestinal mucosa has resulted from the massive infection. Photographed at magnification of 100X.

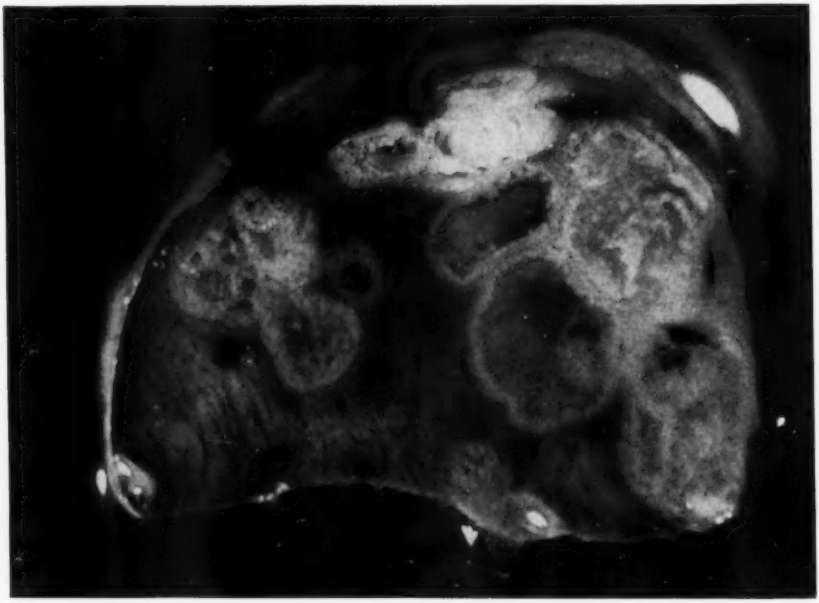

Fig. 5. Alveolar echinococcosis. Cross section of the liver of a common field vole, 166 days after experimental infection. Greatest width of this lobe actually 19 mm. Total infected organ weighed 2 grams more than remainder of animal's body.

take several forms. Godfrey (1937: after Dew, 1928) listed a variety of cutaneous, gastro-intestinal, respiratory, cardiovascular, and nervous symptoms of anaphylaxis.

The larvae of *E. granulosus* appear to be essentially non-pathogenic in their natural mammal hosts. However, McTaggart Cowan (1944), writing on infected elk, stated that "Hydatids apparently reduce the vitality of the host to a marked degree." I do not believe that this is the case. In examinations of a considerable number of infected moose, including seven animals killed during the open hunting season in southern Alaska, I have seen nothing which would indicate that they were not in the best physical condition. It is true that the older a moose (and probably an elk as well) becomes, the greater the probability of its being infected. I would expect to find that nearly every aged moose in southern Alaska would harbour *Echinococcus* larvae. Naturally, aged animals would be the most likely to be in poor physical condition, but the *Echinococcus* larvae cannot be considered to contribute to this. I have removed as many as 18 larvae, ranging in size up to 80–90 mm., from the lungs of a moose shot when apparently in excellent condition. The only pathological change I have seen in the lungs of infected moose is a slight proliferation of the connective tissue capsule which encloses the larval mass. I have never found larvae in any other organ in the moose, but de Vos and Allin (1949) reported them from the liver of three Ontario moose, two of which also had myocardial infections.

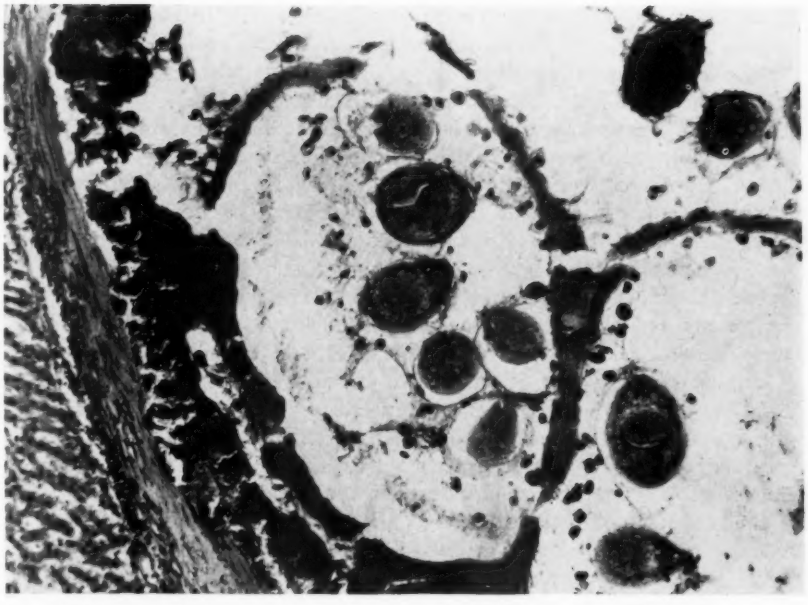

Fig. 6. Histological section of gross specimen in Fig. 5, showing details of structure. Normal liver tissue in lower left corner. Photographed at magnification of 100X.

Considerable information is available on anomalous larval development in some of the domestic animals; these differ in degree of susceptibility to infection.

Alveolar echinococcosis

In some parts of the world (Bavaria, Tyrol, Russia) larvae of *Echinococcus* have been reported in which the structure and method of growth differ greatly from that described above. When man is infected with this form the resulting disease is usually known as alveolar echinococcosis or alveolar hydatidosis. There is no development of spherical, well circumscribed larval vesicles, but instead the larval mass consists of a dense aggregation of small cavities (Figs. 5–6). Larval growth takes place as a progressive irregular invasion of the host tissue.

The status of alveolar echinococcosis is somewhat indefinite, but since this form is much the more malignant of the two, and since it has been reported from Siberia (Pavlovskiy, 1946) and St. Lawrence Island, some discussion is necessary here. It may prove to be a serious problem in the north. There are two main theories on the disease: first, that two different diseases exist, caused by different species of *Echinococcus*; second, that there are two larval forms of the same species, which cause different tissue reactions.

In a recent work, Henschen and Bircher (1945) have concluded that alveolar echinococcosis is caused by the larvae of another species of *Echinococcus*, which they designated as *Taenia echinococcus alveolaris* as opposed to

T. echinococcus hydatidosus (*Taenia=Echinococcus*). These writers claimed that the adult cestodes of the species producing the alveolar larvae could be differentiated on a morphological basis.

On the other hand, Wardle and McLeod (1952) stated: "The restricted geographical distribution of the infestation has induced suppositions that the adult worm—which has been reared by several observers in dogs—is specifically distinct from *granulosus*; but the zoological evidence to that effect is not convincing, and it is noteworthy that no investigator has succeeded in provoking alveolar hydatidosis in experimental animals".

Alveolar hydatidosis has, however, been produced regularly in the Arctic Health Research Center laboratory by feeding *Echinococcus* eggs, taken from arctic foxes and dogs on St. Lawrence Island, to certain rodents (especially voles). It is clear from the results of infection experiments that the species of cestode occurring on St. Lawrence Island and Ostrov Beringa (Bering Island) is immunologically different from *E. granulosus*. Consequently, I am of the opinion that alveolar hydatidosis is caused by a distinct species of *Echinococcus*. The adult worms have not been differentiated morphologically, and this may not be possible. It is noteworthy that this species does not occur on the continent of North America unless recently introduced through the transport of infected dogs. In the voles primary infection is always in the liver. There is, however, metastastic spread of larval elements to new foci, and this may result in generalized infection. Experimental infection of voles in the laboratory has shown that nearly complete liver destruction may occur, resulting in the death of the host. This has been discussed in more detail by Rausch (1952).

In the alveolar type of infection a malignant invasion of a given organ—usually the liver in man—takes place, with the result that the tissue is destroyed and replaced by the parasite tissue. According to Henschen and Bircher (1945) alveolar type larvae usually localize in the subdiaphragmatic zone of the right lobe of the liver. In man the centre of the larval mass often becomes necrotic, producing a cavity which may have a capacity of as much as 6 litres. I have not had any human material for study, but I have not observed this necrosis in experimental animals. Henschen and Bircher have discussed the pathogenicity of this form in detail. They mentioned that new foci of infection may originate through metastasis.

Diagnosis and treatment

Human hydatid infection may be diagnosed in several ways. Roentgenological examination may disclose the presence of the larvae under favourable conditions. Diagnosis by this method has been discussed by Godfrey (1937). Serological tests are valuable, particularly when used in conjunction with other diagnostic aids. The intradermal Casoni test, using non-specific antigen, is relatively accurate, as is the complement fixation test. The latter, however, requires good facilities. Clinical symptoms may be important,

depending on the localization of the larva. The need for better knowledge and diagnosis of this disease has been shown in Alaska, where recently several cases of pulmonary infection have been erroneously diagnosed as tuberculomata, and surgical treatment was consequently inappropriate.

Treatment consists of surgical removal of the larval mass. This is ordinarily feasible when *E. granulosus* is involved, but in some cases the operation is difficult or impossible because of the location of the parasite. The larval mass is dissected free and removed entire. Some advocate the withdrawal of some of the fluid and its replacement with 10 per cent formalin to sterilize the organism before removal is attempted; this may be dangerous. In any event, great care must be taken to prevent perforation or rupture of the larva. Loss of fluid may cause anaphylactic shock, and there is also danger of recurrent growth of the organism from generative elements contained in the escaping fluid. In the latter case, recurrence of the disease may be expected within five to ten years. In inoperable cases the prognosis is grave.

Most cases of the alveolar form are considered inoperable. Treatment might be possible with an early diagnosis, but the prognosis is usually poor. Diagnosis of this form is difficult, since it can be mistaken for carcinoma or other non-parasitic conditions. The surgical treatment of alveolar hydatid disease is discussed in detail by Henschen and Bircher (1945). They advocate a radical resection of the infected hepatic lobe in cases where the larva is somewhat isolated, and a series of operations for the gradual eradication of the larval mass if it is diffuse.

Occurrence in northern countries

In attempting to compile information on the occurrence and importance of hydatid disease in northern countries, I have found that records are often scarce or difficult to obtain. The scarcity of records from some countries (such as Finland), would seem to indicate lack of knowledge or inadequate medical facilities rather than any rarity of the parasite. This is particularly the case when dealing with nomadic populations and remote regions. Alaska is a good example of the latter, having a population of a few hundred thousand people scattered over a vast country, with medical service available to a small proportion only of the total. A similar situation exists, apparently, in northern Canada, Lapland, and Siberia. Although important omissions probably exist, I shall attempt to survey the occurrence of hydatid disease in man and lower mammals in all northern countries.

Russia

Hydatid disease is of frequent occurrence in Russia, if one may judge from the numerous titles which have appeared during the last few years in the Russian medical literature. Most of these works have been concerned with the clinical aspects of the disease, and I have not obtained any papers which give detailed information on distribution and incidence of human infection. References to hydatid disease in Russia are frequent in the European literature.

Pavlovskiy (1946) devoted ten pages (pp. 330–9) in his book on human parasites to the general discussion of hydatid disease, with particular reference to control. I have not obtained any other recent Russian book on helminthology.

Söderhjelm (1946) has reviewed much Russian literature not available to me. According to him: Romanovitch (1913) observed *Echinococcus* larvae in reindeer in the area around Tobol'sk; Grühner (1924; cited after Skrjabin, 1931) reported the larvae from reindeer from the Yakutsk region, the Chukotskiy Poluostrov (Chukotsk Peninsula), and Kamchatka; Skrjabin (1931) recorded the parasite from reindeer around Arkhangel'sk and Okhotsk; Vinogradov (1933) reported a case from the Kol'skiy Poluostrov (Kola Peninsula).

Pavlovskiy (1946) stated that human cases of alveolar echinococcosis were observed yearly in Irkutsk (eastern Siberia). Barabash-Nikiforov (1938) found almost 50 per cent of the red-backed voles (*Clethrionomys rutilus*) on Ostrov Beringa to be infected with the alveolar larvae. Afanas'yev (1941) concluded that *C. rutilus* was the only intermediate host of "*Echinococcus granulosus* (Batsch)" on Ostrov Beringa.

Pavlovskiy emphasized the occurrence of the disease on the collective and state farms where sheep were raised, and it is evident that the problem in its classical cycle of dog and sheep as the two hosts exists in the regions of Russia where this industry is important.

Finland

The status of hydatid disease in Finland is not known. According to Mr. Eero Muroma, Game Biologist, Finnish Institute for Game Research, hydatid disease "is very rare in our country" (personal communication). A recent list of parasites occurring in wildlife (Muroma, 1951) does not include *E. granulosus*. On the other hand Söderhjelm (1945) reported two cases of pulmonary echinococcosis confirmed in evacuees from Finland, and noted that the disease had probably not been previously recorded from the country. He stated (1946) that evacuees from Lapland had told him of finding larvae in reindeer from the vicinity of Enontekiö, and since reindeer are infected in Russia it would be unlikely that the reindeer in Finnish Lapland would have escaped. Further, the regular use of dogs in herding reindeer in Lapland would seem to ensure good conditions for the completion of the life cycle of *Echinococcus*. Further investigation is needed.

Norway

Hydatid disease in Norway appears to be restricted to the regions where reindeer are kept. Harbitz (1913, cited by Söderhjelm, 1946) stated that since 1859, when the first observation on echinococcosis was made in Norway, several cases had been observed in reindeer, particularly from the Tromsö district. Hellesnes (1935, cited by Söderhjelm, 1946) reported infected reindeer from Sjåk, Lom, and Böverdalen in southern Norway. Pulmonary infection in reindeer from Karasjok in northern Norway was mentioned by Qvigstad (1941). I have not found any record of infected Norwegian 'elg' (*Alces*; called moose in North America), although it might be expected to be an intermediate host of this parasite, as it is in North America.

Sweden

The occurrence of hydatid disease in man and reindeer in Sweden was reviewed by Söderhjelm (1945), and the following records are taken from his work. Since 1938, when the first case of human pulmonary infection was reported, a total of 40 cases has been diagnosed in the Sandträsk sanatorium. These were all thought to have originated in Norrbotten län (Norrbotten province). Since the known ratio of liver to lung occurrence is approximately 70 to 20, it was concluded that a much larger number of undiagnosed liver infections must exist.

Among 60 reindeer slaughtered in Kuuri, near Kåbdalis, in 1941, 3 animals had lung infections; while among 70 slaughtered in 1944, 7 infected animals were recorded. In the same year no infected animals were found among 31 calves and yearlings killed at Laver. Among 20 forest reindeer (*skogsrenar*) killed in 1941 at Rödingsträsk one infected animal was found. However, no infections were noted among 300 forest reindeer killed in 1945.

Iceland

The highest incidence of human infection so far reported from the northern hemisphere existed in Iceland during the early part of the last century. There is some disagreement of data, in view of the methods used, but it is apparent in any case that a very grave situation existed. Schleisner (1849, cited by Dungal, 1946) estimated that one out of 7 persons appeared to be infected (based on the examination of 326 patients). It should be pointed out that these figures are based on cases which were clinically diagnosed, and consequently the total figures should be greater because of the large number which would remain undetected. Finsen (1874, cited by Dungal, 1946) found 298 persons infected in an examination of 7,044, or one out of every 22.6 persons. Finsen thought this figure too high, and estimated that actually only about one out of 50 persons was infected. Bjarnhjedinsson (1905) reported on the incidence of hydatid disease in autopsies carried out at the leprosy hospital at Reykjavik; he observed larvae in 26 out of 86 people examined. Dungal (1946) reported on a total of 1,231 autopsies made over a 15-year period (1930–44). Sixty cases of hydatid disease were noted (one of every 20.5 persons). Dungal concluded that the incidence of infection increased with age, and that one of every 6 persons over 60 years of age was infected.

Ofeigsson (1937) stated that the incidence of infection in Iceland had greatly diminished. On the other hand the data presented by Dungal indicate that the problem is still an important one.

Canada

According to Magath (1950) the first recognized native-born case in Canada was observed in Quebec in 1900. Since that time, enough information has been assembled to show that the parasite has a wide distribution, and it has recently become apparent that the disease may be important in some of the more northern parts of the Dominion.

In 1937 Magath (1937), on the basis of 482 North American human cases for which information was available, was able to determine that only 3 persons

had been infected in Canada. He concluded that most Canadian cases involved immigrants (particularly from Iceland) who had been infected in other parts of the world. The same writer later reported (1950) that about 700 cases had been diagnosed in North America. Regarding hydatid disease in Canada, he wrote: "James and Boyd stated that hydatid disease was comparatively common in Canada, Iceland and Australia and that it was particularly common in Manitoba on account of the large number of Icelandic immigrants in the province. From table 6 it can be seen that hydatid disease was never common in Canada and in the past twenty years only 9 cases have been reported, and only 3 from Manitoba. Truman said that 35 cases had been diagnosed in Winnipeg General Hospital between 1923 and 1942, but of these only 2 have been reported so far as I can determine. Hydatid disease has disappeared from Iceland and the Icelandic immigrants to Canada have almost all died".

Wild animals in Canada are often parasitized by *E. granulosus*. Hadwen (1932) reported *E. granulosus* from moose, *Alces alces* [*sic*], at The Pas, Manitoba. Law and Kennedy (1933) also reported it from the moose. More recently, de Vos and Allin (1949) collected this parasite from three moose killed in northwestern Ontario and noted that "the digestive tracts of most timber wolves from northwestern Ontario examined last winter contained tapeworms. *Echinococcus granulosus* was the most common species recovered. . .".

The occurrence of *Echinococcus* larvae in North American wild mammals, has been reviewed by McTaggart Cowan (1948). He reported larval cestodes from black-tailed deer, *Odocoileus hemionus columbianus*, taken at Crofton, Vancouver Island, and from mule deer, *O. h. hemionus*, and elk, *Cervus canadensis nelsoni*, in Jasper and Banff National Parks. Infected wolves were also reported. Dr. McTaggart Cowan kindly lent me specimens from these animals, and examination showed that all have the typical larvae of *E. granulosus*. Banfield (1952) observed the larval stage of *E. granulosus* in the lungs of two barren ground caribou out of 54 critically examined.

Though relatively few, these records indicate that *E. granulosus* is widely distributed in Canada. Whether or not it is an important human parasite remains to be determined. The Department of National Health and Welfare is currently conducting a survey of this disease, and it is anticipated that their results will do much towards making known its importance to human health.

Alaska

Early records of the occurrence of *E. granulosus* in Alaska are few. Hadwen and Palmer (1922), in a footnote, stated that *Taenia echinococcus* (=*E. granulosus*) was found in Alaskan dogs in 1914 by E. C. Joss, U.S. Bureau of Animal Industry. Hadwen and Palmer also mentioned this parasite in connection with their Alaskan reindeer investigations but did not give any specific locality records. They did, however, state that the cestode larvae were not found in St. Lawrence Island reindeer.

The first Alaskan record of hydatid disease in man appears to be that of Magath (1941). Williams (1948) reported the occurrence of a pulmonary

infection in an Indian woman from the upper Tanana region. Human cases are being diagnosed rather frequently in the native population in Alaska. It is to be expected that many more will be found with increasing awareness that the disease occurs in the Territory.

In early 1949 the Animal-borne Disease Branch of the Arctic Health Research Center at Anchorage undertook the investigation of hydatid disease and related problems in Alaska among the animal population. This work has been continued on a Territory-wide basis since that time, with the result that considerable information has been accumulated. A detailed report will be published separately, but a few general remarks will be included here.

It has been found that moose are commonly infected with *E. granulosus* in some localities. This animal appears to be the important intermediate host, and probably serves as the main source of infection for canine animals over much of the Territory. So far I have examined only one infected caribou—an old bull killed near the Black River, north of Nelchina. Mountain sheep may sometimes serve as the intermediate host of *E. granulosus*, but I have no information on this point despite the examination of a good series of these animals.

Canine animals, both dogs and the wild species, frequently harbour the adult cestodes. As many as twenty-five per cent of the dogs in some of the arctic villages may be infected, and more than 10 per cent of all Alaskan wolves examined harboured the adult cestodes. Infected coyotes so far have not been observed, but the series examined has been relatively small.

On St. Lawrence Island the cycle involves two species of microtine rodents, *Microtus oeconomus innuitus* Merriam and *Clethrionomys rutilus albiventer* Hall and Gilmore. The arctic fox is the main final host, but infected dogs are not uncommon. The characteristics of the life cycle and epizootiology of the cestode on St. Lawrence Island have been discussed in other publications (Rausch and Schiller, 1951; Rausch, 1951, 1952). It is of unusual interest that this cestode is identical in its life cycle characteristics with that reported on Ostrov Beringa by Barabash-Nikiforov (1938) and Afanas'yev (1941). Although both authors referred to it as *E. granulosus*, it is obviously not this species. I have no doubt that it is identical with the St. Lawrence Island species, but it is not possible at present to assign a specific name[1].

Animal cycles involved in hydatid disease

Before control measures can be considered, an understanding of the epidemiology of hyatid disease is necessary. Human infection results from close association with canine animals harbouring the adult cestodes, but the interrelationships involved may be quite complex. Man's control of certain animals may adjust their behaviour to the point that conditions for survival of the parasite are optimum (e.g., the reindeer–dog association brought about

[1] A vole infected with *Echinococcus* larvae has recently been obtained by Dr. Jean G. Baer, Université de Neuchâtel, Switzerland (personal communication). This is of special interest in connection with the frequent records of alveolar disease from south Germany and Switzerland.

through usual husbandry methods). Four major categories of animal associations may be differentiated in northern countries; these are discussed briefly.

1. *Cycle involving dogs and sheep*

In Iceland, as well as in parts of Russia, dogs and sheep are involved in the life cycle of *E. granulosus*. Infected dogs kept constantly with the flock disseminate many eggs which are ingested by grazing sheep. Dogs, in turn, are infected by eating sheep viscera containing the larval cestodes.

Human infections occur frequently under such conditions, as is shown by the situation in Iceland. This does not always result, however, from a direct transmission. The surface of the ground may be heavily contaminated by dog feces, and sheep lying in the area often have many eggs adhering to their wool. Pavlovskiy (1946) pointed out that the incidence of infection among the women, who are concerned with shearing and otherwise caring for the sheep, is significantly greater than among the men. The eggs also adhere to the fur of dogs, from which they may be transferred to the hands of those having contact with them, or they may fall off inside the dwellings. Dogs gentle enough to associate with children transfer eggs through licking the face and hands during play. Eggs can be carried into the house on footwear or equipment. The threat of human infection under such conditions is constant.

2. *Cycle involving dogs and reindeer*

Hydatid disease is connected closely with reindeer management in northern Norway, Sweden, and Finland. This has also been the case in a few places in Alaska. Although the reindeer may ingest eggs directly while feeding, other modes of infection no doubt exist. Söderhjelm (1946) suggested that reindeer may ingest cestode eggs when they eat snow soaked with dog urine, and that the urine of female dogs especially might dislodge eggs from the perianal region. The eating of urine-soaked snow for its salt content is a well known habit. Since the snow would often be eaten within a short time it is likely that the eggs would escape damage from low temperatures.

Under present conditions in Lapland up to 10 per cent of the reindeer of certain herds may be infected. There appears, however, to be less opportunity for human infection than in the dog–sheep cycle.

3. *Cycle involving wild and domestic canids and wild ungulates*

In boreal North America (from the northern boundary of the United States) *E. granulosus* is a ubiquitous parasite of wild canine animals and ungulates, and several different cycles of infection probably exist. Since reported by Riley (1933) from moose in Minnesota, its occurrence in this animal has been more-or-less emphasized. The moose apparently serves to transmit the parasite to dogs as well as to wild canids over much of Canada and Alaska. For instance in the vicinity of Palmer, in the heavily cultivated Matanuska valley, almost every aged moose is infected, and I estimate that the larvae may be found in at least 50 per cent of the adult animals. Wolves are rare or absent in the Palmer area, so other species must serve as the final host. In view of their method of feeding, it is surprising that moose have much

opportunity to ingest eggs. Investigation of the mode of natural infection of moose would be worthwhile. I have no positive information on occurrence of *Echinococcus* larvae in moose in Eurasia. A recent paper by Machul'skiy (1950) on the parasites of moose in Buryat-Mongoliya does not mention any species of *Echinococcus*.

Although caribou are much more abundant than moose and their feeding habits would seem to be conducive to picking up *Echinococcus* eggs, infected caribou are relatively few. Of more than 200 caribou examined, I have observed only the one infected animal mentioned above. Eskimo in the Brooks Range have, however, told me of finding structures in the lungs of caribou which almost certainly were *Echinococcus* larvae.

In the Anaktuvuk Pass region of the central Brooks Range wolves commonly harbour the adult parasites. Of the 121 wolves I examined 25 per cent were infected. Both wolf and caribou occur on the same range. Since wolves very rarely capture caribou which are not diseased or otherwise weakened, it must be assumed that aged animals make up a large proportion of their kill. Consequently, the chances for wolf infection would be enhanced. I wish to emphasize though that the fact that the wolf is involved in the life cycle of this cestode does not constitute any appreciable threat to human health and this information should not be construed as support for those in favour of generalized wolf destruction.

Both red and arctic foxes are host to *E. granulosus* in Alaska. The way in which foxes obtain infected viscera of ungulates is not known with certainty; presumably, from time to time, they find carcasses from which they feed. Infected foxes have little importance as far as man is concerned. There might be some risk involved for trappers skinning infected animals, and it is possible that edible vegetation might be contaminated by fox feces.

The only real threat to human health comes from infected dogs. In the outlying villages where dogs provide the sole means of transport, large numbers are tethered in the immediate vicinity of the dwellings. The children play among them, where fecal contamination of the ground is massive. It is not uncommon for frozen meat or fish to be stacked on the ground round the houses, where it may be urinated upon by untethered dogs. This urine might contain eggs. In summer, freshly killed meat of caribou or moose often has considerable contact with the ground before being cached. In addition to the eggs carried into the dwellings on footwear and other articles, they may be brought in on the fur of the dogs themselves. In some places the dogs come freely into the houses; in other villages only bitches with small puppies are permitted inside. The crossbar of the dog harness is almost always much soiled by excreta. Hence there is opportunity for direct contamination of the hands and clothing whenever the animals are harnessed, often by the girls and women, or when harnesses are taken inside for repair.

It is evident that ample opportunity exists for the ingestion of the cestode eggs during the course of everyday activity in Eskimo and Indian villages. Water contamination is still another means of egg dissemination. According to Pavlovskiy (1946) the eggs of *E. granulosus* survive up to 10 days in water.

4. *Cycle involving wild and domestic canids and mouse-like rodents (Microtus and Clethrionomys)*

This relationship is the least known, having only recently been recognized as distinct. It has been discussed above, and need not be considered further here.

Control

Control of hydatid disease depends on the elimination of infected dogs. The required program is largely one of prophylaxis, since human infections are better prevented than treated. Certain procedures are appropriate in attempting to reduce the number of human cases through dog control and sanitation. The main points of the control program put into effect in Iceland were enumerated by Ofeigsson (1937). Those which have general value are listed here: "Better hygiene; the rapid spread of the knowledge of the life cycle of the parasite among doctors and laymen, who realize the importance of breaking the cycle; more and better doctors; laws forbidding all unnecessary dogs; a quarantine once or twice a year, of all dogs during which they would be treated with baths and suitable drugs; warnings to people against too much petting of their dogs and careful washing of their hands after touching them."

It is evident that improved sanitary conditions, destruction of excess dogs, and education of the people are important procedures in the control of hydatid disease. Remedial programs appear to be in effect in most of the northern countries where the importance of the disease has been recognized for many years. In the remote regions of Eurasia—Lapland and Siberia—it appears that much is yet to be done.

In Alaska and parts of Canada, where the disease is receiving attention for the first time, little progress has been made towards initiating a control program. The Alaskan Command has put into effect an order prohibiting the export of all dogs from St. Lawrence Island and the arctic coast regions of Alaska by members of the military forces. A similar quarantine regulation for civilians is being prepared by the U.S. Public Health Service. One of the most important things is to prevent the St. Lawrence Island form of *Echinococcus* from being introduced into continental North America.

The lack of adequate medical assistance, combined with poverty, poor diet, and a low level of education contribute towards a high morbidity in aboriginal people in Alaska. It may be premature to attempt to control a disease of the relatively small importance of echinococcosis until tuberculosis is brought under control. Fortunately, improved sanitary conditions will affect both. One cannot hope that the living standards of Alaskan Eskimo and Indians will immediately improve, but it would be possible, through public health education, to lessen the importance of hydatid disease. There is need throughout Alaska for drastic reduction of worthless dogs; this would affect rabies as well as hydatid disease, and would conserve much food which could be utilized by the human population. Legislation appears to be the only means by which this could be brought about. Through education it would not be difficult to create an understanding of the dangers of feeding infected

animal parts (e.g. moose and caribou lungs, etc.) to dogs. Further, dogs should be tethered at a reasonable distance from human dwellings; along the coast the gravel beaches would be a most suitable place. Although no anthelminthic is known which can be depended upon to eliminate all the adult parasites from the intestine of dogs, periodic treatment would at least reduce the infection. On St. Lawrence Island measures would be necessary to prevent the dogs eating the voles. Again, keeping the dogs tethered and on the gravel beaches would assist this, since the rodents rarely leave the cover of vegetation.

There is need for making the situation known to medical practitioners. The majority of physicians trained in the United States are not adequately familiar with hydatid disease, since it is given little more than passing mention in most medical schools. Contrary to the current opinion, it should be recognized that echinococcosis is of importance in North America. Medical workers should especially be aware of the consequences if alveolar hydatid disease were to become established in continental North America.

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SOME PROBLEMS OF INSECT BIOLOGY IN THE CANADIAN ARCTIC*

T. N. Freeman†

THE Northern Insect Survey was begun in 1947 as a joint project supported and administered by the Defence Research Board, Department of National Defence, and the divisions of Entomology and Botany, Science Service, Department of Agriculture, Ottawa. The main objects of the survey are to study the distribution, relative abundance, and biology of the species of biting flies and other insects in the arctic and subarctic regions of Canada. The results of this survey have not been completely compiled to date, although sufficient data have been analyzed to permit some general comments on the insects of the North. By the end of 1952 forty-six areas will have been investigated, including five areas in Alaska and one in Greenland for comparative purposes (see Fig. 1). Each year approximately 125,000 specimens are collected, including several new species and many extensions of previously-known ranges.

Our studies of the species of insects indigenous to the arctic tundra have clearly demonstrated the close relationship between the nearctic and palaearctic faunas and that many of the species have holarctic distributional patterns. The collections indicate two major and two minor faunal divisions in northern Canada, each division containing certain insects that are restricted to it. The major divisions may be defined as the northern boreal forest and the arctic tundra, the minor ones as the Cordilleran system and the Labradorian or Gulf of St. Lawrence area. Many insects of the boreal forest also occur in the Cordilleran and Labradorian regions, but it is significant that the phytophagous insect species of the northern forest do not invade the tundra. The northern boreal forest is inhabited by a great diversity of insect genera and species which are distributed from Alaska to southern Newfoundland. The arctic tundra, however, is inhabited by comparatively few species, most of which appear to be distinct from those in the northern boreal forest, although usually belonging to the same genera. For example, at least 38 species of mosquitoes occur in the boreal forest, whereas only 4 species are found in the tundra. This is typical for other insect groups. However, most of the tundra species occur in great abundance and the total insect population is large, although the number of species is relatively small. The Labradorian and Cordilleran regions are peculiar in that they have a few representative species, as well as many species of the boreal region. Within each region are many problems of inter- and intra-specific variability.

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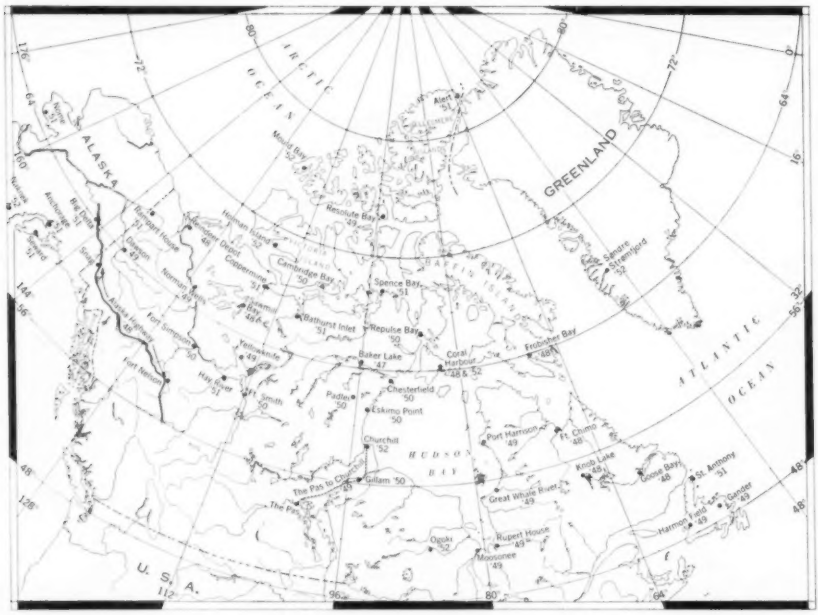


Fig. 1. Areas investigated on the Northern Insect Survey.

The insects of the Arctic, particularly the Lepidoptera, show a considerable amount of individual variation within the species—for example, some of the species of *Colias*, or sulphur butterflies. *Colias nastes* Bdv. is found throughout the Arctic on dry sandy or gravelly ridges. Another species, *Colias hecla* Lef., occurs at the bases of the ridges and hills. In the areas of Baker Lake, Southampton Island, and the Boothia Peninsula, another form or species called *Colias boothii* Curt. is found in the same habitats as *hecla*. Some specimens of *boothii* look like *hecla* and some like *nastes*, and because of the extreme variability of *boothii* it has been suggested that this species is a natural hybrid between the two other species. However, *boothii* and *nastes* have not been found to interbreed in all the areas investigated, and it is possible that *boothii* may be merely a geographical race of *hecla*. The dry hilltop species *nastes* also shows considerable variability, and certain variants of both *nastes* and *hecla* resemble each other, and perhaps it is this type of variation that represents the third form, *boothii*. It is hoped that further study and collecting will solve this puzzling complexity of the interrelationship of the *Colias* butterflies of the tundra.

It is obvious that the arctic insects have dispersed in the tundra region in the recent geological past, following the retreat of the Pleistocene ice sheets. This glacial epoch no doubt considerably affected insect distribution and speciation. The insects living at present in the Arctic are the progeny of those populations that lived in the refugia, which are known to have existed

in the ice from earlier botanical work. Huge tongues of ice, must have separated the existing species into isolated populations; and in part, because of this isolation and environmental pressure and selection, these eventually evolved into distinct species or subspecies. It is probable that those species in the coniferous zone evolved along the southern periphery of the ice sheet, well isolated from those living in the refugia in the ice. Present distributional patterns indicate that the major refugia were situated in the Yukon, in Alaska, and possibly in Siberia. Minor refugia, which produced the present Labradorian fauna, must have existed in Labrador, Newfoundland, or perhaps the Gaspé Peninsula. As the ice retreated the insects must gradually have increased their distributional ranges.

The arctic regions present a rather monotonous and uniform insect environment. It appears that since the ice retreated insufficient time has elapsed for the development of many diverse habitats, and specific dominance of plants in large areas is hardly noticeable. It is possible that this lack of variety of habitat is partly responsible for the small numbers of insect species in the arctic regions as compared with the number of species in the wooded areas farther south. However, many arctic insects, like the *Colias* butterflies, are remarkable migrants. As a result there is some gene interchange between geographically isolated populations. This genic interchange, as well as modifications of the local environmental pressure, is at least partly responsible for the phenotypic and genotypic variability within the species and may also, in part, perhaps explain the lack of evolution of many distinct species since the last glaciation.

A CARIBOU HUNT ON PEARY'S 1898-1902 EXPEDITION

Clarence F. Wyckoff

Introduction

During the four years 1898–1902 of the first Peary north polar expedition, the Peary Arctic Club sent a ship north each summer to visit and resupply the expedition. In the summer of 1901 Clarence F. Wyckoff accompanied the *Erik*, an auxiliary steam whaler chartered by the club because Peary's ship, the *Windward*, had not returned the previous summer as expected. The *Windward*, with Mrs. Peary and her daughter aboard, had been forced to winter at Payer Harbour, Ellesmere Island, but had broken out by the time the *Erik* reached Etah on August 4. Peary records[1] that "both ships pressed into the work of hunting walrus, until August 24th, when the *Windward* proceeded southward, and the *Erik* steamed away to land me and my party and the catch of walrus at Payer Harbour." Heavy ice prevented their reaching Payer Harbour, and the party was landed some 12 to 15 miles south of Cape Sabine. On August 29 the *Erik* sailed for Sydney, N.S.

The following account of a caribou hunt in west Greenland by Clarence Wyckoff has been sent to us by his widow. The hunt described probably took place about 13 August 1901 when he had transferred to the *Windward*.

[*Editor Arctic*]

PEARY had sent us into the Ulrick's Bay[2] country for reindeer. Our boat, the *Windward*, had worked well up to the head of the bay where a stream tumbled down from the high interior. Here we knew we could make our way inland as this side of the bay was a favourite hunting ground for the Eskimo. The other shore of the bay rose straight up and on that side the Eskimo had never hunted.

In this section as we learned from the Eskimo, there were many deer. The hills were indented with valleys where the sun, shining twenty-four hours a day, warmed the meagre soil, permitting moss and grass, and even some flowers, to mature. This made a splendid feeding ground for the deer.

As our first objective was to become familiar with the country we planned a twelve-hour hunt. We landed and found the going fairly easy. After working up into the hills, we branched out, each of the six white men going in different directions. A few Eskimo had been loaned guns and they also scattered.

My companion was a young Eskimo named Cawingwa. Unfortunately for me he had never before hunted deer and was not of much help. And help was what I needed.

There were deer aplenty. My first sight of them was as we climbed up over a rim rock on to a fairly wide plateau. There they were over against a low hill—a dozen of them. For at least five minutes we stood and stared while the deer looked us over. Finally I remembered that I was out to get

[1]Peary, R. E. 'Nearest the pole'. London: 1907, p. 335.

[2]Presumably Olrik Fjord, Inglefield Bredning, called Olriks Bay by Peary. [*Editor Arctic*]

A meal on board the *Windward*. Admiral and Mrs. Peary and daughter Marie to the right; Clarence Wyckoff at the extreme left.

food for Peary on his dash for the pole. Estimating the distance at about eight hundred yards I adjusted the sights of my gun accordingly; then took aim and fired. The deer came to life and one and all galloped away, disappearing into a pass in the hills.

After my shot I had noticed what looked to be flying fragments of rock at a point less than half-way to where the deer had been. I decided to investigate. I paced off the distance to the rock and found it to be nearly a thousand yards. And the spot where the deer had been seemed as far away as ever. When I reached the place where the deer had stood I had covered more than three thousand yards.

I thought of the story of the man in the Rockies who had started to jump a brook and found he was swimming a river. It was apparent that I would have to revise my ideas of distance. The air was so rare and pure that far-away objects seemed to be in the immediate foreground.

Though before returning to the ship I saw many more deer I was never able to get within range. It seemed impossible to stalk them. The only cover was an occasional boulder and the deer were sure to see a movement as you dodged from one stone to the next. If they happened to be down wind they did not wait for the movement. And how they could run! With their large antlers covered with velvet they looked awkward and top-heavy—until they got under way.

I returned to the ship a very disappointed hunter only to find the others not much better off. The only white man who had made a kill brought in but two deer. The Eskimo had had better luck, bringing in nine. We had to have forty or fifty head for Peary's party.

Our next move was to establish a camp about ten miles inland. Toting in a tent and supplies we prepared for a three-day hunt. It was a wonderful country. We were close to the edge of the ice cap, but with the sun shining for a few hours flowers were blossoming, the yellow poppy being most common. Lakes were frozen over, stream water was ice cold, yet in the sunshine you could sleep in the open with a light sweater for cover. When the sun went behind a cloud you woke up.

The hunting proved not as successful as we had hoped. Mine in fact was a complete failure. The deer were as wild as Adirondack deer the second day of the open season. The Eskimo were fairly successful, but the white men could not learn the native technique. Toward the end of the second day I grew desperate and decided to keep at it until I had at least one deer to my credit. After hunting for thirty hours on end I returned to camp exhausted and still without my deer. I saw plenty of them, but in the three days I had never fired my gun. I just could not get within range. The open country and constant sunlight where you could be seen for miles were too much for me.

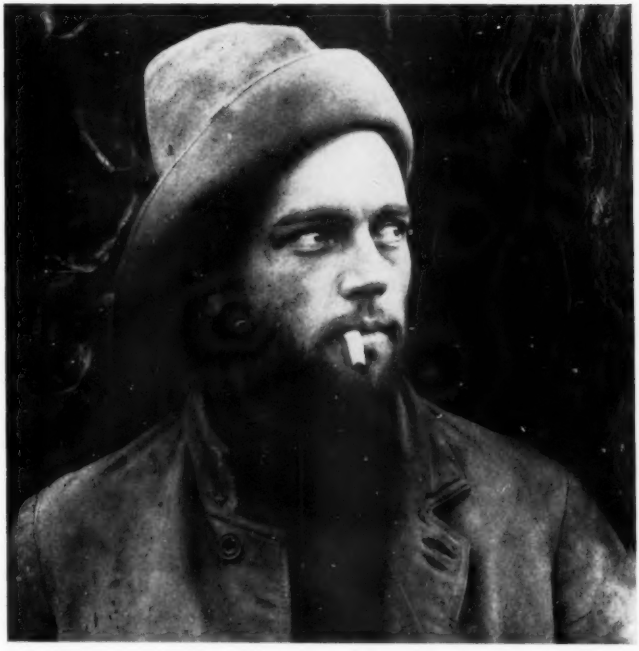
After a six-hour sleep I awoke to find everyone in and making ready to return to the ship. There was nothing to do but admit failure and go back with the rest. When we got to the ship we discovered to our surprise that it was early morning. We had unconsciously lengthened our day until we were twelve hours ahead of ship's time. With the sun always looking as if it had just risen it required the ship's routine to keep track of the time of day.

On arrival we were told that Koolatingwa, one of the more experienced hunters of the tribe, had been ashore on the opposite side of the bay and had found many deer. He had been loaned a gun and twelve cartridges and when he returned he was very apologetic. He had wasted two cartridges—he had killed only ten deer. Dr. Cook was arranging to send out six Eskimo to bring them in.

Here was a last chance to get a head and I immediately joined the party. I offered Koolatingwa a hunting knife if he would show me how it was done. He was delighted and said the knife was his if I would follow him and do exactly as he did.

Koolatingwa had found a deer trail up the mountain side which we followed. According to the captain's calculations the climb was about three thousand feet and I judge he was under rather than over. The Eskimo climbed like goats. When they would get three or four hundred feet ahead of me they would all sit down and watch with much amusement my attempts to reach them. It was all loose shale and at every step I was as liable to slide back as to go forward. When we finally made the top we found a large lake, frozen over, in the immediate foreground. We crossed this and made for a high point of land beyond.

From the top of a small hill I saw spread out before me a large plain, fairly level and dotted all over with caribou. There were literally thousands of them. It looked as populated as an old Texas cattle range. The animals were fairly tame. Those nearby ran but soon stopped and began grazing.



Clarence Wyckoff on a hunting trip in Greenland. Muskox skin in the background.

Koolatingwa told me to pick out the head I wanted and we would get it. I selected the nearest one. He again cautioned me to do as he did and started out to circle the deer so that we would have it to windward. The remaining Eskimo hid in a pile of rocks.

We advanced for perhaps half a mile in plain sight of the deer before he noticed us. When he looked up Koolatingwa, who was just ahead of me, stopped but remained standing—not moving a muscle. I also became a statue. The deer looked us over for a minute or two, evidently decided we were a part of the scenery, and went back to grazing. As soon as his back was turned, Koolatingwa started on again and I followed. Every time the deer looked up we froze in our tracks and the deer would always go back to grazing. In this way we walked up to within a hundred feet of the animal and I decided I was near enough. I stepped to one side and fired. Koolatingwa looked around and I could see he was disgusted with me. I think he had planned to get near enough so that if necessary he could have killed the deer with an axe. Of course the Eskimo had been accustomed to get their deer with a spear and I have no doubt that Koolatingwa had been within a few feet of the ten deer he had shot. My wonder now was why he had wasted the two cartridges.

I had hit my deer in the fore shoulder and he dropped in his tracks. As we walked toward him he managed to get up on three legs and started to run. I brought my gun to my shoulder to put him out of his misery, but

Koolatingwa knocked it aside, yelling, "Naga, naga", ("No, no"), and started running for the deer. On went the deer on three legs and I started after the two. As I caught up with and passed Koolatingwa I again attempted to use my gun, but with another "Naga, naga", he sprang in front of me, still chasing after the deer. Finally it dropped and when we got up to it it was stone dead. Then Kootlatingwa explained: "The deer was going toward the big boat".

I had not been paying much attention to direction but when I looked around I found we were back near the pile of rocks where the five Eskimo were hiding. At a word from Koolatingwa the five began tossing the stones from the pile and it developed that this was one of Koolatingwa's caches. Three deer had been covered with stones to keep the foxes away from them. When the deer were uncovered the five gathered around one of the carcasses, cut slices from it, and began eating the raw meat. Koolatingwa who had been helping me skin my deer soon joined them.

There were still many deer in sight peacefully feeding. They had all run at the sound of my gun, but not far. Probably never before had they seen a human being. We were not far from the ice cap and a cold wind was coming from it. Dressed in light hunting clothes I had not noticed the temperature while I was active, but now I suddenly discovered I was cold. I picked up the warm deer skin and wrapped it around me. Its warmth was welcome and I soon realized that I was hungry. The three ship's biscuits I had put in my pocket before I left the ship were long since gone. I looked at the Eskimo. They seemed to be enjoying their cold deer. Finally I sat down with them, cut a strip of meat from the deer's hind quarter, and gingerly tasted it. It was delicious. That was one of the best meals I ever had. As a wind-up an Eskimo would cut out a bone, crack it between two stones, and with a thumb extract the marrow. I tried that also and it proved a fitting dessert to a wonderful meal.

When an Eskimo has plenty of food he gorges, and after eating, sleeps. After their feast my Eskimo arranged themselves on the ground in a closely knit bunch, lying on their sides in a circle, the head of each man on the thigh of the one ahead. In this way they slept, huddled together for warmth. I was tired and could have slept, but decided instead to return to the ship. We had all the deer the men could carry and with Koolatingwa's bag a total of forty-six deer—quite enough for Peary's wants. I cut off my deer's head and started with it for the frozen lake, leaving the Eskimo still asleep.

I was a long time getting down to the shore. When I arrived the antlers were no longer in velvet. What with the heavy head on my back and the loose shale I fell many times in working down the mountain. When I arrived at the ship I had been travelling constantly, except for six hours sleep, for seventy-two hours. I got one of the other men to care for the head and dropped into my bunk for a twenty-eight-hour sleep. My deer hunting was over.

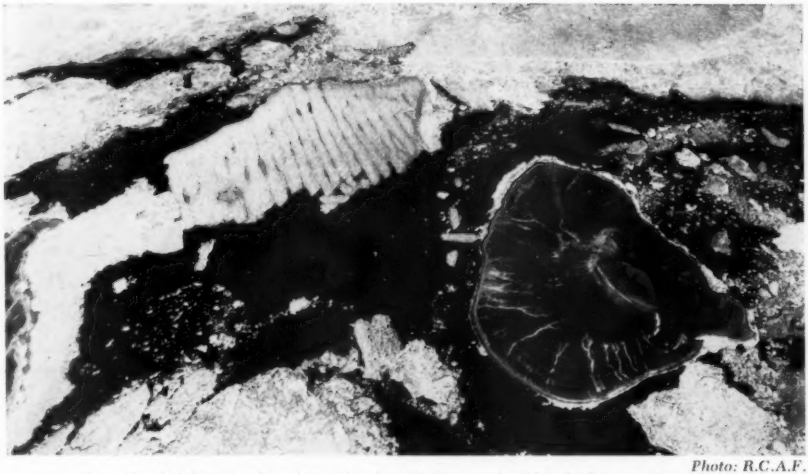


Photo: R.C.A.F.

Fig. 1. Disintegrating ice island off Exmouth Island, Norwegian Bay.

FURTHER NOTES ON ICE ISLANDS IN THE CANADIAN ARCTIC

As part of a study of the distribution of sea ice in the Canadian Arctic[1], an intensive survey has recently been made of all available air photographs taken during the summers of 1947–52[2]. The papers on "Arctic ice islands" published in the July number of *Arctic* (Vol. 5, pp. 67–103) had anticipated that future surveys would discover ice islands not then recorded. Thirty-one new ones have now been noted and their locations are indicated on Fig. 3—a revised version of the original map. Most of them are small, some being only about ¼ or ½ mile square. The largest, approximately 7 miles long by 6 miles wide, was photographed in June 1948 in M'Clintock Channel off the west coast of Victoria Island. It has proved, however, to be merely the replotting of an island noted previously but wrongly located (at 82°54N., 104°30W. instead of at 72°54N., 104°30W.) as the result of a misreading of poorly-written coordinates on the back of the photograph. As a large ice island had been reported near the former position, no error was suspected.

Figure 3 shows that the general distribution of ice islands remains much the same as originally mapped although the recent observations have extended their range to include the following five areas, one of which reaches south to the coasts of the mainland:

(1) *Axel Heiberg* (*west coast*): several islands, mostly small. Two islands (or bergs) in Strand Fiord have not been shown on the map as they appear to be of local origin and have probably come from the large tidewater glacier on the north shore of this inlet. They may be compared with the Greely Fiord bergs mentioned in *Arctic* (Vol. 5, pp. 81–2).

(2) *Norwegian Bay*: two islands. Figure 1 shows that the one off Exmouth Island is in an advanced stage of disintegration.

(3) *M'Clintock Channel*: one large island and several small ones located off the coast of Victoria Island.

(4) *Queen Maud Gulf*: two small islands off the mainland coast.

(5) *Prince Patrick Island* (*west coast*): one small island off Lands End.

[1]See note p. 195.

[2]This survey was made by Miss Mary C. V. Douglas and Miss Jane McCarthy of the Defence Research Board, Canada.

In three areas the persistence of ice cover over a number of years became evident from the survey. The ice island noted off Otto Fiord in August 1948 is now known to have been in the same position in July 1947. It thus presumably entered Nansen Sound some time in 1946 at the latest. All ice floes in the area retained their respective positions, indicating that the island was not grounded but that the ice in this part of Nansen Sound had not broken up during these years.

Ice islands which were observed on the U.S.A.F. survey photographs in 1948 off the west coast of Axel Heiberg were still in their same positions in 1950. Two of these islands were located in 1946 in Sverdrup Channel, one on either side of the boundary line between the moving pack of the Polar Basin and the ice of the channel. In 1950 the island on the channel side was still in its same position, but the one on the northern side of the boundary had moved off, presumably to drift westward with the prevailing current. The shape of this island suggests it may be one of the two seen to the north of Isachsen Peninsula in 1950, but this cannot be definitely determined from the photographs.

In August 1947 an ice island was seen between Amund Ringnes and Haig-Thomas islands. The only open water in the area was a narrow shore lead which barely reached its extreme tip. In August 1950 the ice island was in the same position, surrounded by the same floes. The latter had now been considerably smoothed by surface melting, but the ice island appeared to be unchanged except that the tip had broken off along one of the surface furrows and had drifted a short distance towards the Amund Ringnes coast.

The existence of a northward drift along the west coast of Boothia Peninsula is suggested by the fact that the ice island observed in Peel Sound, north of Bellot Strait in 1950 is now known to have been some 50 miles to the south in Wrottesley Inlet in 1949.

In the course of the survey, two unexplained land-ice features were noted in the interior of Ellesmere Island. The first was a narrow "lake", bounded at each end by a glacier, which lies approximately 15 miles up the valley leading to the

Photo: R.C.A.F.

Fig. 2. Head of the western arm of M'Clintock Bay, Ellesmere Island, showing the roll ice merging with that of the bay-head glacier. The outline of what appears to have been the tongue of a glacier which has now retreated, is seen in the right centre of the photograph.

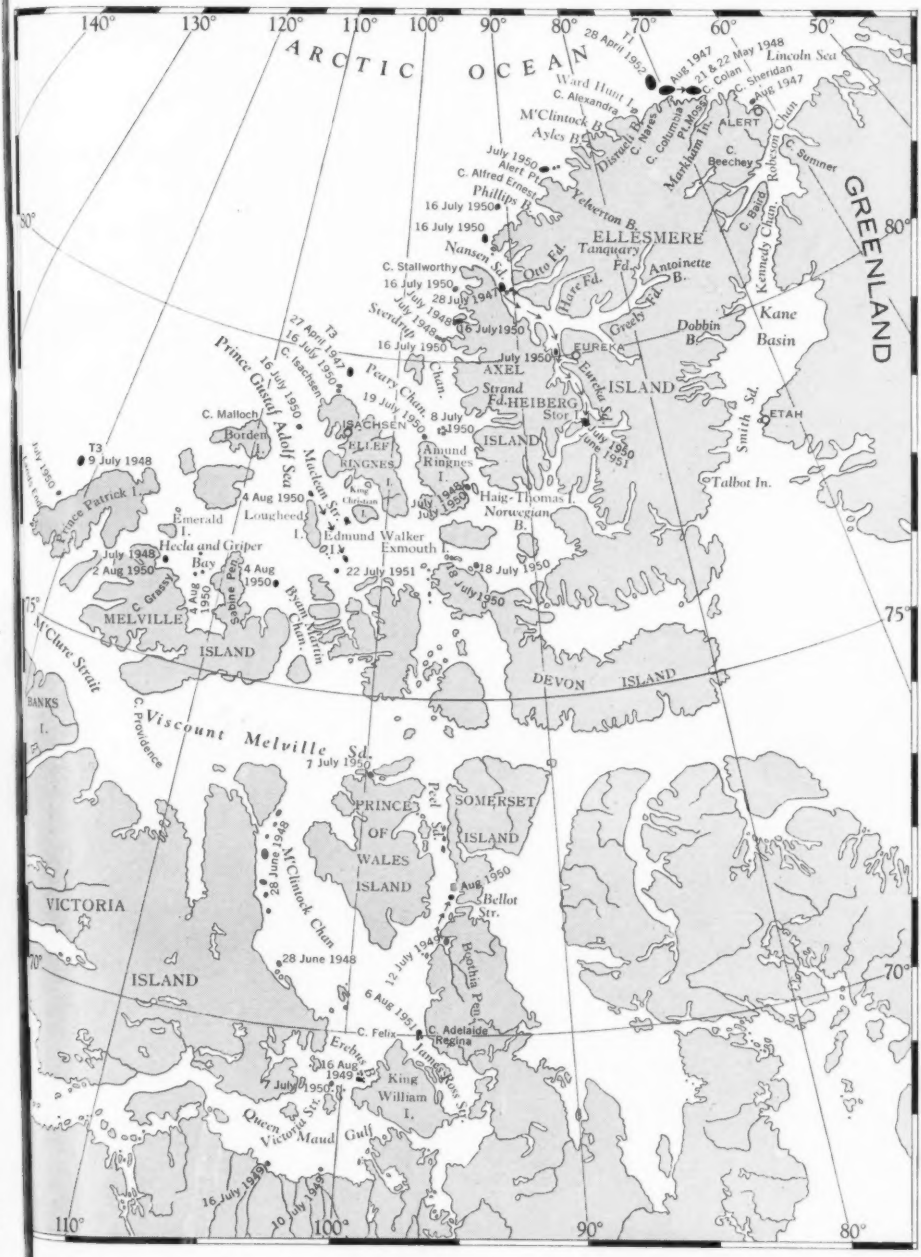


Fig. 3. Ice islands noted on air photographs in the Canadian Archipelago. The new islands are shown in red. The areas of the ice islands are not correct for scale, but do give their approximate relative sizes.

Photo: R.C.A.F.

Fig. 4. Glacier-bounded "lake", in the valley leading to Ayles Bay, Ellesmere Island. Yelverton Bay is seen in the distance.

Photo: R.C.A.F.

Fig. 5. "Lakes" on an ice field in central Ellesmere Island. The surface markings resemble those along certain stretches of the north Ellesmere Ice Shelf.

southeast arm of Ayles Bay (Fig. 4). The surface pattern is similar to that of the Ellesmere Ice Shelf and the direction of the undulations appears unrelated to pressure from the glaciers at either end. No explanation can be advanced from present evidence but the possibility that this is a fragment of relic ice, overridden by present-day glaciers, is suggested by the conditions observed on an arm of M'Clintock Bay some 30 miles to the north (Fig. 2). Here, at the south end of the bay, the roll ice merges with the outflow from an active glacier, while farther north a dark outline suggests the moraine left by a small valley glacier, which must at one time have advanced over the older ice and then withdrawn without modifying the surface to any appreciable extent.

The second inland feature is the group of "lakes" lying just east of the great Chapman Glacier on the ice field between Hare and Tanquary fiords (Fig. 5). The surface pattern of these bears some resemblance to that of the Ellesmere Ice Shelf.

Another interesting ice feature was noted in the 1952 photographs of Talbot Inlet on the east coast of Ellesmere Island. Here a very small stretch of what appeared to be shelf ice was located in the triangle between two large glaciers and an offshore island. The surface markings in this area are similar to those seen in some of the smaller bays along the north Ellesmere coast.

MARGARET R. MONTGOMERY

REVIEWS

THE SCANDINAVIAN STATES AND FINLAND: a political and economic survey

By Royal Institute of International Affairs. *Toronto: Oxford University Press, 1951. 8½ x 5½ inches; 312 pages; sketch-maps and folding map. $4.50.*

Chatham House, the headquarters of the Royal Institute of International Affairs in London, has a well-deserved reputation for the timeliness and impartiality of its studies about international questions of the day. This volume is the work of a small group of authors under the leadership of G. M. Gathorne-Hardy. After a short introduction it deals with five areas in detail: Denmark, Finland, Iceland, Norway, and Sweden. There is also a booklist and there are a few maps.

Those concerned with the Arctic will find the parts of the book which deal with the northern areas of Scandinavia of greatest interest—and the preface encourages readers to expect a good deal with the statement: "Recent developments in the possibilities of long-distance air travel combine with the events of the last world war to reinforce the lesson that, in addition to Denmark, Norway, and Sweden, the remoter Scandinavian regions of Iceland, Greenland, the Faeroes, and Spitsbergen have now acquired a quite new and possibly considerable strategic importance", and the first map shows the relationship of the Scandinavian states to the north pole.

The reviewer looked for a section on Spitsbergen with anticipation, to discover six lines. Iceland receives somewhat fuller treatment in fourteen pages, with a sketch-map. This section deals with the land and its resources, history, social structure, political structure, economics, and commerce.

Each of the larger countries is dealt with at length. They will not be discussed here except in so far as near-arctic areas are concerned. In the Norwegian section one looks in vain for any discussion of the reconstruction of Finnmark following the destruction by the Nazis, or of the elaborate North Norway Plan which has been under discussion for some time. There is a reference to the rebuilding of the Sør Varanger iron mines near Kirkenes and the fact that production is once more going on.

Little information is supplied on Finnish Lapland, apart from a passing comment on the loss of the Petsamo area to the U.S.S.R. in 1944. No mention is made of the cession of an additional and strategically significant area to the U.S.S.R. in 1947. This latter area includes the dam controlling the water level of Lake Inari and the Jäniskoski power plant which provides energy for the Salmijärvi nickel refinery. The map at the end of the volume shows the U.S.S.R.-Finnish boundary wrongly at this point. This map is unsatisfactory in other ways, especially in the omission of such significant places as Hammerfest and Kirkenes, and its unexpected inclusion of a small Lapp village Utsjoki.

Of far northern areas, Greenland receives the fullest treatment, for it is given a section of its own, totalling seven pages. There is a useful summary of the history, administration, resources, trade, social services, strategic value, and exploration, in that order. The booklist indicates that most of the source material is somewhat out-of-date, the newest account being a popular wartime production for the United States Air Force, 'War below zero'. Events have changed so rapidly in Greenland in the past five years that it is a pity that the authors did not have their manuscript checked by Danish officials. For example, in referring to wartime meteorological facilities, it is suggested that Denmark is finding it difficult to man and finance some of them. No mention is made of the large grant received annually for some years from I.C.A.O., and the remark that "only skeleton staffs are maintained at the few important airfields" is

misleading, because the few important fields are manned by the U.S.A.F., while the unimportant one is not manned at all.

Under "Administration" it is stated that "Greenland is administered by a special department in the Danish Ministry of the Interior"—this is not the case, since it is a branch of the Office of the Prime Minister.

Reference to resources emphasizes the Ivigtut cryolite mine and its great importance to the Greenland budget. The mine is of course not operated by the Pennsylvania Salt Company (p. 69) nor has it ever been so. It is owned jointly by the Danish Government and a private Danish corporation. The authors are apparently unaware of the fundamental change in the Greenland economy due to a shift from production of seal and other oils, to commercial fishing, especially of cod.

Should a further edition of this useful handbook on the Scandinavian States and Finland be called for, Mr. Gathorne-Hardy and his committee could perhaps refer the parts of it dealing with Lapland, Spitsbergen, and Greenland to the appropriate governments for amplification and correction. TREVOR LLOYD

CLIMATE OF THE CANADIAN ARCTIC ARCHIPELAGO

By R. W. RAE. *Toronto: Department of Transport, Meteorological Division, 1951. 11 x 8½ inches; 90 pages; maps and diagrams. 35 cents.*

This welcome publication by a meteorologist widely experienced in arctic climates replaces the old 'Meteorology of the Canadian Arctic', which had been out-of-date and out of print for some years. The new study is a great improvement on the old, and is a vital addition to the documentation of the north. The author was in charge of the joint Canadian/United States weather station at Resolute Bay, Cornwallis Island, for a considerable period; he has drawn on this experience and on the files of the Canadian Meteorological Service in completing his report. He pays tribute in his introduction to the unpublished work of W. C. Wonders on the same region. It is clear, none the less, that the principal source upon which he drew was his own unrivalled fund of memories.

Mr. Rae proceeds along traditional lines. He discusses successively the controls of climate, temperature, precipitation, clouds, visibility, winds, and relative humidity. The formal account is followed by forty invaluable pages of tabulated climatic data, which will be of great value to other research workers. Some of this wealth of material has been represented cartographically in a series of twelve distribution maps (the first to be published for the Canadian Arctic Archipelago based on adequate data).

The cold pole of the Canadian Arctic is now placed in northern Ellesmere Island, where January is believed to have a mean temperature of below -40°F; indeed, the new weather stations in the outer fringe of arctic islands have made it clear that we have been partially misled in our thinking about winter cold by the concentration of stations along and near Lancaster Sound, which is anomalously warm in mid-winter presumably because of partially open water. Isachsen, Mould Bay, and Eureka have all experienced minima of below -60°F, in spite of the briefness of their record, whereas Arctic Bay has never attained this degree of cold in fourteen years of record. Mean temperatures in January and February are below -30°F over a wide area of the archipelago, whereas they are above -20°F along Lancaster Sound.

The new stations have reinforced to an astonishing degree our preconceived idea that the outer islands were very dry. Total annual precipitation at Eureka has averaged only 1.74 inches in the three or four years of record. The total rainfall for the period January 1948 to December 1950 was only 1.44 inches (a figure sometimes exceeded in a single day at Ottawa or Washington) and fresh snow amounted to less than 15 inches in each of the three years (cf. Montreal, 112 inches average annual fall). To some extent these figures are vitiated by the extreme difficulty of

measuring fresh snowfall, but they cannot be far from the truth. The arctic "deserts" are a proven reality.

Mr. Rae discusses the annual cycle of cloudiness in considerable detail. In commenting on the gloomy, overcast skies of summer, he lays special stress on the double maximum of cloudiness characteristic of central and southern parts of the archipelago. In spring and early summer there is widespread marine status and sea fog that partly dissipates later in the summer, only to reform as temperatures fall below freezing in the autumn. Mr. Rae ascribes this stratiform cloud-deck to the trapping of moist, chilled air below the usual radiative inversion of temperature. He states, however, that the cloudiness of autumn tends to consist of more turbulent stratocumulus layers, probably due to higher wind-speeds; otherwise the process of formation is similar. This may be so in the archipelago; but stratocumulus decks are equally extensive farther south in the same season, and frequently form in deeply unstable polar air that is heated from below by residual open water. Inversions are frequently absent in such instances, and the "layer" habit of the autumnal cloud remains something of a mystery.

There are one or two points in Mr. Rae's treatment at which I must cavil. I wonder how many of the convolutions of the 40°F isotherm on the July temperature map (Fig. 11) are based either on observational material or on topographic probabilities. It is also plain that on the same map Mr. Rae made little use of available statistics from the nearby mainland. Thus the 50°F isotherm pursues an erratic course that bears little relation to reality: it passes on Fig. 11 north of Port Harrison (which has a July mean of only 47°F) and far to the south of Churchill (54°F), Baker Lake (50°F), and Coppermine (50°F). This is an unfortunate lapse in view of the importance attached to this line by biologists. The closed loop of the 60°F isotherm that is obviously supposed to lie over Goose Bay (62°F) misses it by some hundred miles; the 55°F line passes right through the site of the airbase. It is quite true that these criticisms apply only to the mainland, whereas Mr. Rae was addressing himself to the archipelago. But it is inevitable that these maps, covering as they do a large part of the arctic and subarctic mainland, will be widely copied for this larger purpose, and it is unfortunate that they are by no means of uniform reliability.

In all other respects, however, the new report is a thoroughly useful and well-conceived contribution to arctic science. It is to be hoped that studies of similar scope will soon be forthcoming for other parts of the Northland.

F. KENNETH HARE

NORTH OF THE CIRCLE

By FRANK ILLINGWORTH. *New York: Philosophical Library, 1952. 8½ x 5½ inches; 254 pages; illustrations. $4.75.*

As far as can be determined the objective of 'North of the Circle' is to prove to a lay reader that life in arctic areas may be comfortable rather than harsh. It is questionable whether the series of anecdotes related accomplishes this objective. Otherwise, the book is a more or less pleasant ramble which in total is incomplete, in part inaccurate, mostly undocumented, inadequately illustrated, and quite possibly over-optimistic.

Mistakes in fact are legion. For instance: "up the Yukon towards the Bering Sea" (p. 40); "no [agricultural] ground pests" (p. 68) though severe damage has been caused over the years by root maggots and cutworms in arctic vegetables; every statement but one about the Matanuska Valley on p. 73; "The Russians did not want to sell" Alaska (p. 152) in spite of historians' statements to the contrary; the Alaska purchase "was the largest single deal in real estate in history" (p. 153) ignoring the 40 per cent larger Louisana Purchase just sixty-four years previously; the Malaspina Glacier "covers fifteen hundred square miles" (p. 153) although shown to be only 900–1,000 on the most recent maps; discussion of the periods of Alaskan development (p. 155) omits the beginning of fishing, Alaska's greatest industry; the Alaska Rail Road suc-

ceeded the Alaska Northern rather than Alaska Central (p. 157); and paper money certainly was in use in Fairbanks prior to the Second World War (p. 160).

Equally misleading is the looseness of writing throughout and the many misspellings of place names which make it appear doubtful whether the author read the proofs of the book. For example: he defines the Arctic as north of the "53rd Isotherm" (p. 4) without stating whether the line is for the year, winter, or month and without staying in this defined area for the rest of the book; inferring the ease of hearing wood chopped in -60°F temperatures (generally considered almost too cold for this pursuit) to the low temperatures (p. 44) rather than the temperature gradient; a declaration that the Bering Straits are strategically analogous to the English Channel (p. 247) which is subject to serious question; and the statement that "there could be no doubt" that Russia would move into eastern Alaska in case of hostilities (p. 247) which omits consideration of the bigger task of holding an area after it has been captured.

Other incorrect statements are those too optimistic. There is doubt that the thousands of soldiers who were in the Arctic during the last war returned with stories of "conditions suitable to a population of millions" (p. 21), and that Alaska and eastern Siberia are what "the Americans call 'the most strategical areas on earth'" (p. 245).

Finally, the omissions in the text are a cause of concern. The absence of any map is inexplicable. On page 158 the description of Alaskan towns omits Anchorage, Alaska's biggest centre. The gold strike at Fishwheel, Alaska (p. 163) was 'salted', though details are given which do not suggest this. Chapter 10, The Russian North, covers 9 pages as compared with 27 on Spitsbergen and without mention of the Northern Sea Route Administration responsible for Siberian development north of 62° latitude or of population distribution or changes[1]. Development of the Quebec–Labrador iron ore deposits is unreported as well as the decline of the Icelandic herring fisheries with the northward shifting of ocean currents (p. 239).

It is perhaps too much to expect a book on the Arctic for the lay reader to be complete, scientifically accurate, and easily understandable. However, it is fair to hope for an organized approach which aims at completeness of coverage with the same degree of detail and which includes data in easily accessible statements, photographs, maps, and statistics.

KIRK H. STONE

[1]See article by C. J. Webster, "The growth of the Soviet Arctic and Subarctic", *Arctic*, Vol. 4 (1951) pp. 27–45.

INSTITUTE NEWS

McGill University–Arctic Institute Research Program

During the past summer several graduate students were in the field carrying out research work under this Program.

D. J. Osborn, J. S. Bleakney, and G. A. Schad travelled through northern Quebec from Seven Islands via Knob Lake to Fort Chimo on a joint biological investigation of small mammals, amphibia, and animal parasites. F. G. Ridge studied townsite planning in the Northwest, visiting points on the Mackenzie from Fort Smith to Aklavik and also several Yukon settlements. R. L. Monahan and R. Young drove to Alaska, where the former was engaged in work on settlement possibilities in the Fairbanks district and the latter in microclimatic studies on the tree line in the Matanuska Valley. J. S. Mercer, assisted by Weston Blake, carried out glaciological and geomorphological work on the Grinnell Glacier, Baffin Island.

For 1952–3 the Senior Fellowship under the Program has been awarded to W. R. B. Battle, from Cambridge University. Mr. Battle has carried out glaciological research in Norway and Greenland, and will be in Baffin Island next summer with the expedition which P. D. Baird, Director of the Institute's Montreal Office, plans to lead.

Scholarships have been awarded to Messrs. Schad, Mercer, and Monahan (continuing) and to H. R. Thompson, D. Ellis, and A. Watson. H. R. Thompson is a geographer from Oxford and Illinois universities, and D. Ellis and A. Watson are zoologists from Scottish universities.

Research grants awarded for the summer of 1952

During the summer of 1952 the following carried out research work with the aid of Institute grants:

Cooch, F. G., Cornell University: the Blue Goose.

Dehnel, P. A., University of California: marine invertebrates in the Ketchikan region, Alaska.

Fay, F. H., University of British Columbia: Pacific walrus.

Findlay, Marjorie C., Sheep farming in Greenland.

Hansen, H. P., Oregon State College: Pleistocene and post-glacial forests in British Columbia and Alaska.

Humphrey, P. S., University of Michigan: ecology of sea ducks in the Hooper Bay area, Alaska.

Huckett, H. C., Long Island Vegetable Research Farm: the arctic and subarctic muscidae (laboratory study).

Laughlin, W. S., University of Oregon: Aleutian anthropology.

Lepage, Rev. E., Ecole d'Agriculture, Rimouski, Quebec: botany of the James Bay region, Canada.

Lucier, C. V., University of Alaska: culture of the Noatak Eskimo, Alaska.

Miller, M. M., American Geographical Society: glaciological research on the Juneau Ice Field, Alaska.

Moir, D. R., University of Minnesota: floristic survey in the Severn River region, Ontario, Canada.

Sharp, R. P., California Institute of Technology: glaciological research on the Saskatchewan Glacier, Canada.

Van Stone, J. W., University of Alaska: archaeological work in the Aleutian Islands.

'Science in Alaska'

At the First Alaskan Science Conference, held in Washington, D.C., in November 1950 under the auspices of the National Academy of Sciences–National Research Council, the Institute undertook to publish a volume of selected papers, representative of those presented at the Conference. This volume has recently been published as Special Publication No. 1 of the Institute. 'Science in Alaska' was edited by Dr. Henry B. Collins of the Smithsonian Institution

and contains the complete text of 23 papers. Copies may be obtained from the Washington Office of the Institute, 1530 P Street N.W., Washington 5, D.C., U.S.A. Price $2.25 postpaid.

The titles of the papers included are as follows:

Agriculture and Forestry

Status and accomplishments of agricultural research in Alaska. By Don L. Irwin.

Alaska forest research problems and program. By R. F. Taylor.

Anthropology

Survey of southeastern Alaskan Indian research. By Viola E. Garfield.

Present status of the Alaskan Eskimos. By Margaret Lantis.

Preservation of archaeological and ethnological material in Alaska. By Frederica de Laguna.

Preservation of archaeological remains in Canada. By Diamond Jenness.

Contemporary problems in the anthropology of southeastern Alaska. By W. S. Laughlin.

Ancient Bering Strait and population spread. By J. L. Giddings.

Botany

Botanical research in Alaska. By William C. Steere.

The future of botanical research in Alaska. By Ira L. Wiggins.

Geology and Geography

Glaciological research in Alaska. By William O. Field, Jr.

Some geographical bases for planning new Alaskan settlement. By Kirk H. Stone.

The hydrology of Alaska. By Arvi O. Waananen.

Geophysics

Geomagnetism—cosmic and prosaic. By David G. Knapp and Elliot B. Roberts.

The Geophysical Institute at the University of Alaska. By William S. Wilson.

Meteorology

Agro-climatological investigations in the permafrost region of the Tanana Valley, Alaska. By Basil M. Bensin.

Public Health and Medicine

Water supply problems in low temperature areas. By Amos J. Alter.

Relationships of permafrost to environmental sanitation. By Amos J. Alter.

The psychological aspects of arctic and subarctic living. By Ernest L. McCollum.

Zoology

Planning for Alaska's big game. By Olaus J. Murie.

Pressing problems in administration of wildlife resources in Alaska. By W. A. Elkins.

Management of the marine resources of Alaska. By Seton H. Thompson.

Alaskan waterfowl and their management. By Ira N. Gabrielson.

NORTHERN NEWS

Conference on Eskimo affairs[1]

A round table conference on Eskimo affairs was held in Ottawa on May 19-20. Major-General H. A. Young, Commissioner of the Northwest Territories, was in the Chair and eight federal government departments and agencies, the Roman Catholic and Anglican missions, and the Hudson's Bay Company were represented. Economic conditions, Eskimo morale, health, and education were the main subjects discussed.

The difficult economic problems caused by the periodic fluctuations both in white fox population and the value of white fox fur have been intensified by the decline in value of white fox pelts to less than $5.00 in 1951 and the general marked rise in the cost of trade goods. Government aid, such as family allowances and old age and blind pensions, has made the Eskimo aware of the fact that they now have two sources of income and are not solely dependent on trapping. Their independence is being weakened in some areas by the knowledge that government agencies will come to their assistance. As a result less effort is being devoted to trapping and the Eskimo are concentrating at settlements, resulting in a rapid depletion of the accessible country produce. This in turn has led to decline in vitality and resistance to disease. In the seven years

[1]Reprinted from the *Arctic Circular*, Vol. 5, No. 4 (1952) pp. 41-3.

1945-51 Eskimo relief costs totalled $405,000 and other aid such as family allowances brought the figure from government sources during that period to $1,687,000. In the Baffin Island-Ungava area 53 per cent of the Eskimo's income came from government sources, while in the Western Arctic the figure was about 25 per cent. It was agreed that Eskimo should be encouraged and helped to live off the land and to follow their traditional way of life.

The conference was very concerned with the deterioration of health among the Eskimo. It was admitted that the present health organization is far from adequate in so large an area and among so scattered a people. Nevertheless the bare maintenance cost of the current services is $355,000 a year and if all related costs are added the total would be about $1,000,000. Reports indicate that the spread of tuberculosis among the Eskimo is increasing seriously. Dependence on supplies of white man's food and poor game conditions in some areas, and the delay in the isolation and removal to hospital of active cases are contributing causes. An effective program for the treatment and removal of active cases and for the rehabilitation of arrested cases is necessary. It was agreed that the possibility of using discharged patients in the Great Slave Lake fisheries and similar occupations less arduous than the normal Eskimo existence should be studied.

The curricula at present provided in the seven territorial schools operated by the Government and the twelve Roman Catholic and six Anglican day schools were discussed at length and the general feeling was that there is room for improvement. New types of text books were suggested and greater emphasis on practical training was recommended. The employment of the older Eskimo at certain settlements is depriving the younger generation of the training which they would normally have received from their parents and many children are unfitted to follow the traditional mode of life. An effort to provide some of this training should be made in the schools. The conference was in agreement with a proposal to employ Eskimo teachers when available and wherever possible to encourage and help Eskimo children of demonstrated ability to become teachers. Whether teaching should be conducted in English or in the Eskimo dialect is a question for further study. It was the view of the missionaries that no real progress could be made in bringing Christian and formal education to the Eskimo unless their economy could be stabilized. The only place in the Northwest Territories that is not seriously affected by the deteriorating influences is Aklavik where the Eskimo, owing to the availability of muskrats and furs other than fox, have living conditions almost on a par with white men. The majority have reasonably clean, well-kept homes, maintain an adequate economy as trappers, and are making definite progress in adapting themselves to civilized conditions.

The Royal Canadian Mounted Police reported that the Eskimo is a law-abiding citizen when his actions are considered in the light of his situation and his view of the law. There are fewer cases of murder as white men know it than there are in what is referred to as the civilized parts of Canada. The force has found it difficult during and since the war to attract and retain personnel for northern duty but the situation is now improving.

The conference also heard suggestions for increases in the number of R.C.M.P. posts and personnel as a means of extending supervision over Eskimo affairs; for establishing government stores or subsidizing the Hudson's Bay Company to operate posts in areas where they were uneconomical at present; for helping Eskimo to regulate their income by establishing a trust fund; and of the possibility of placing a "floor" under fur prices. The conference also discussed the adequacy of fur and food resources to maintain a larger Eskimo population, and the fate of other primitive peoples as a result of contact with modern civilization.

The conference appointed a continuing committee, with General Young as Chairman, to study the reports and suggestions presented at the conference.

Other members of this committee are: Most Rev. J. Trocellier, Roman Catholic Bishop of Mackenzie; Rt. Rev. D. B. Marsh, Anglican Bishop of the Arctic; R. H. Chesshire, General Manager of the Hudson's Bay Company's Fur Trade Department; Commissioner L. H. Nicholson of the R.C.M.P.; Dr. P. E. Moore, Director of Indian Health Service, National Health and Welfare Department; and Mr. J. G. Wright, Chief of the Northern Administration Division of the Department of Resources and Development. The committee will meet in the fall to consider and recommend action. A sub-committee, under the chairmanship of Mr. J. G. Wright and with representatives from various government agencies and both missions, was also appointed to deal with matters concerning Eskimo education.

Canadian Ice Distribution Survey[1]

In 1947 the Geographical Bureau of the Department of Mines and Resources (now the Geographical Branch of the Department of Mines and Technical Surveys) made plans for a long-range study of the condition and distribution of ice in northern Canadian waters. The general purpose of the project was to extend the geographical knowledge of the formation, disintegration, extent, and movement of the different types of floating ice in Canadian waters and the accompanying navigational difficulties. The project includes information on floating ice only, upland or continental glacier ice being excluded except where such glaciers supply ice to the sea as bergs or ice shelves. Originally the area under survey included the Beaufort Sea, the waters of the Canadian Arctic Archipelago, the Hudson Bay–James Bay area, Baffin Bay, Davis Strait, and the Labrador coast. Recently, at the suggestion of the Fisheries Research Board and the Fisheries Division of the Nova Scotia Department of Trade and Industry, the Gulf of St. Lawrence and eastern Canadian maritime waters have also been included. It is intended later to cover all Canadian inland waters.

The project was begun during the summer of 1948 by extracting data on ice conditions from reports published prior to 1905. This work was continued during 1949 and 1950, in which year help in the form of a staff for extraction and editing was contributed by the Defence Research Board, and the information gathered has been filed according to region. As a result of this joint effort, some 2,700 references had been tabulated in the form of cards by 1 September 1952, and these have been sent by the Geographical Branch to certain agencies and organizations interested in ice conditions. Additional references will be distributed as they become available. It is hoped that those receiving the information will contribute to the project by bringing additional references to the attention of the Branch and by sending in authoritative unpublished ice observations.

The information collected will possibly be of most immediate use in estimating ice conditions for specific areas and times. When more information is assembled it should assist navigation, the study of the relationships between ice conditions and meteorological and oceanographic phenomena, and forecasting dates for break-up and freeze-up.

J. KEITH FRASER

Meddelelser om Den grönlandske Kirkesag

Meddelelser om Den grønlandske Kirkesag is a pamphlet which reports the activities of an unofficial but influential committee in Copenhagen interested in furthering church affairs in Greenland. The Chairman is Dr. H. Fuglsang-Damgaard, Bishop of Copenhagen, and the Vice-Chairman and active leader is Provst Aage Bugge. This modest, but useful publication appears at irregular intervals. The most recent pamphlet, No. 79, contains several short articles, two of these, written by Provst Bugge, are of special interest.

The first is an obituary of Provst C. W. Schultz-Lorentzen. Schultz-Lorentzen, who died on 23 March 1951, was a powerful influence in Greenland for more than fifty years, and was the

[1]Reprinted from the *Arctic Circular*, Vol. 5, No. 5 (1952) p. 56.

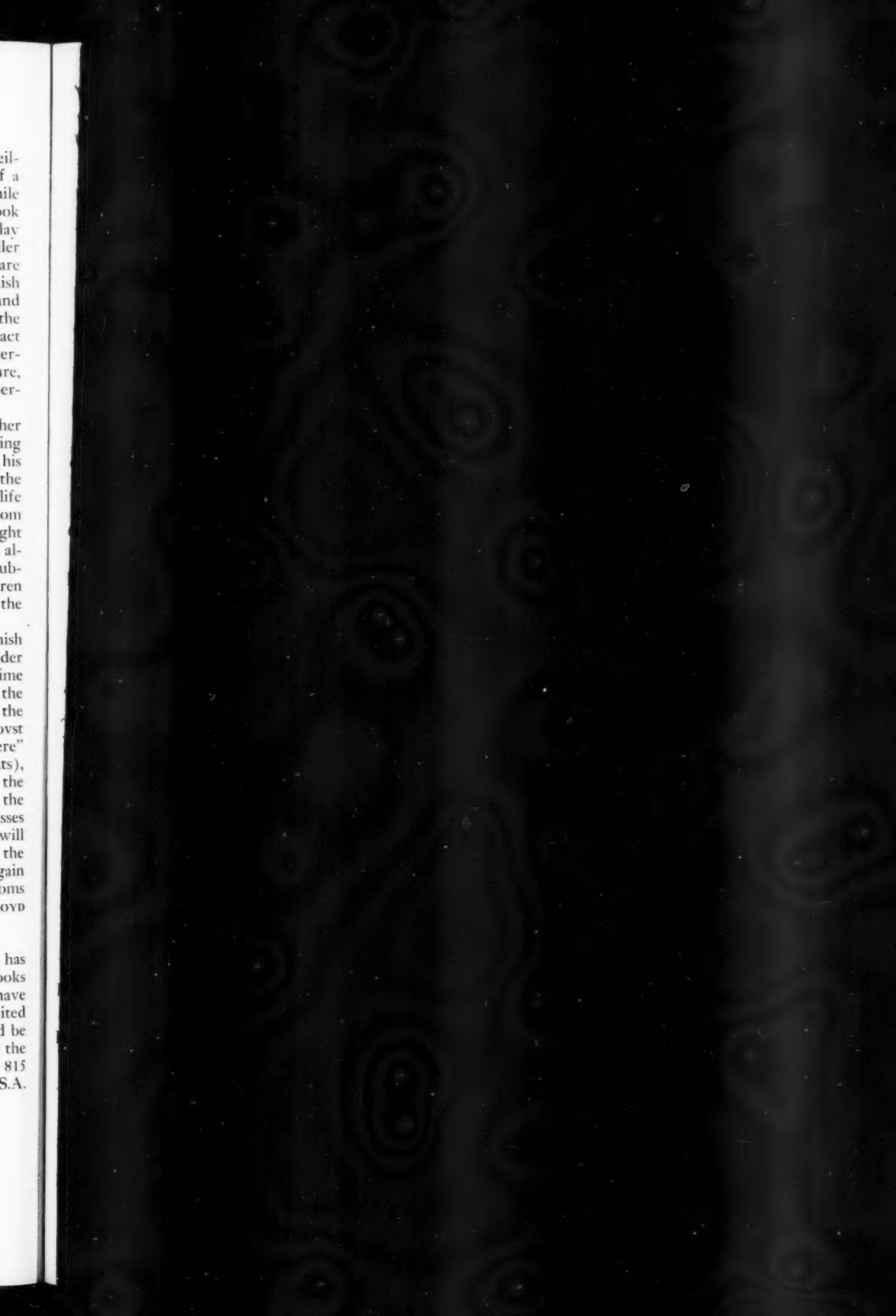
main architect of its church and school system. Outside Greenland and Denmark he was probably best known for the Dictionary and Grammar of the Greenlandic language which he published, in both Danish and English, rather more than twenty years ago. He first went to Greenland from Denmark in 1898 to become a teacher at the Godthaab seminary, then under the leadership of N. E. Balle. Soon after he was transferred to Egedesminde as clergyman and in 1901 he returned to the Seminary as its Principal. From then on he was active in improving the training of lay readers and in modernizing the school system. The present seminary buildings, erected in 1907, are a monument to this period of his work. Students there still use the song he wrote at that time—"*iterta*" (Let us awake!). In 1906 he was appointed Provst of Greenland, a position which gave him direct supervision over all church and school affairs in the colony. Despite these added administrative responsibilities, he found time to continue study of Greenlandic. In 1907 he edited the Greenland Hymn Book, and in collaboration with Rev. Chr. Rasmussen (father of Knud Rasmussen) he revised the Greenlandic New Testament in 1912.

Active as he was in Greenland, Schultz-Lorentzen was equally active while on leave in Denmark. On one vacation he founded the Committee for Greenland Church Affairs (which publishes the *Meddelelser om Den grønlandske Kirkesag*). In 1918 he was appointed "Lektor" and adviser on Greenland church and school matters to the Danish Government, posts which he retained for thirty years. He was an influential member of the Royal Commission of 1920-1 which laid down new lines for social and economic organization of the colony. The principles adopted at that time remained substantially unaltered until 1950 when a new Commission recommended radical changes, including the separation of church and school administration.

Provst Bugge's second article is a long review of a novel in Greenlandic 'Kateketen Johannes', written by Karl Heilmann of Godthaab around the life of a native schoolmaster and lay reader. While well worth reading as a novel, the book is also a valuable study of native lay readers, their training, life in the smaller settlements, and the problems they are faced with as the bridge between Danish ministers in the larger settlements and the scattered villagers. It also shows the clash that may come from the impact of younger, more modern and better-educated men with the more mature, perhaps old-fashioned native teacher-preachers.

The author follows the teacher Johannes from his home in an outlying village, through school, and on to his first appointment. The book shows the intimate knowledge of the everyday life of Greenlanders that we expect from Karl Heilmann, who was himself brought up in such circumstances and has already described them in a novel published during the last war—'Fangeren Samo og Hans Bopladsfaeller' (Samo the hunter and his neighbours).

Because of the pressing need for Danish administrators to understand the older lay readers, who will for a long time continue to be the chief link with the native people, Provst Bugge urges the reading of an article by the late Provst Knud Balle, "De indfødte medarbejdere" (literally the native-born assistants), which appeared as a chapter in the bicentenary volume (1721-1921) of the Greenland Church. He also expresses the hope that 'Kateketen Johannes' will be translated into Danish so that the many newcomers to Greenland may gain an insight into the thoughts and customs of the native people. TREVOR LLOYD

Arctic book catalogue

The Shorey Book Store in Seattle has recently issued a catalogue of their books on 'Alaska and the Arctic'. They have advised us that they have a limited number of copies on hand and would be pleased to send them to Associates of the Institute on request. Their address is 815 Third Avenue, Seattle 4, Wash., U.S.A.